ALPINE RANGELANDS OF THE UINTA MOUNTAINS

Ashley and Wasatch National Forests

Region 4

1970

Mont E. Lewis
Range Conservationist
U. S. FOREST SERVICE

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(Standards and Guides for Classification)

INTRODUCTION

The alpine portion of the Uinta Mountains has an area of nearly 250,000 acres ranging in elevation from 11,000 to 13,500 feet, all within the boundaries of the Ashley and Wasatch National Forests. At present, 32 grazing allotments extend into the alpine. Sheep on these allotments obtain most of their summer forage in the alpine area.

The Uinta alpine country is also one of the most important water producing areas in the State. With this in mind, this area has been carefully studied to determine the compatibility of grazing use with watershed protection and to develop guidelines and criteria for range analysis. The guidelines presented in this report have been used as a basis for training the range analysis technician in doing the field job.

To develop these criteria and guidelines, field observations and studies were made during the 8-year period, 1955-63. These included the selection and analysis of areas in near-pristine condition to set up standards.

Mr. Olaf C. Olson, Chief Regional Soil Scientist, has given much needed aid in the soil phase of the study from 1960 to 1963.

The report consists of two parts. Part I has to do with basic information pertaining to alpine areas and includes discussion of such factors as geology, soils, soil stability, frost action, plant communities, plant succession, and plant trend. Part II deals with the application of the basic information for range classification and management and includes review of range types, range condition and apparent trend, range suitability, and grazing capacity.

Part I - Basic Information

A. Geology

The central part of the Uinta Mountains, which includes the alpine zone, is a broad, plateau-like crest of a geologic arch. Unlike other mountains of the Rocky Mountain system, it has an east-west axis. The north and south edges of the plateau-like crest are sharply broken and thrown into highly inclined positions (King, 1878). The axis of the arch fold is near the north edge of the broad top where it breaks off to the north at a steep angle (see Fig. 1). The highest part of the mountain is the main ridge extending from Mount Emmons to Gilbert Peak. This includes King's Peak, the highest in Utah, with an elevation of 13,498 feet.

The exposed core of the Uintas is pre-Cambrian quartzite, argillites, conglomerates, and micaeous shales instead of a crystalline core common to many mountains of the Rocky Mountain system. Rock colors vary from dark red and maroon to white, with the darker colors being most common. The cementing is dominantly silica, and coloring material is generally ferric oxide. Ritzma (1959) described the Uintas as a large structural arch with a thick sequence of quartzites, argillites, and shales exposed by erosion along the core or axis of the fold. Weathering has broken up the exposed quartzite to form vast boulder fields throughout the alpine area (Fig. 2).

Much of the surface in the alpine zone was altered greatly by ice and snow during successive glacial periods. Glaciers developed in the headwaters and carved out the cirques. As the glaciers moved out of these catchment areas, U-shaped valleys and canyons resulted. Where the cirques were formed in the more gentle plateau-like highlands and where they did not quite coalesce, a "biscuit-board" topography was formed. This is a common landform in the Uinta alpine. Where cirques coalesced, cols and knife-edge spur ridges were formed. The King's Peak area is an example of this latter topography. Most of the catchment areas and glaciers were above 10,000 feet. At the glacier's greatest advance, 1,000 square miles were covered with ice. With the retreat of the ice, a complex mass of drift material was left behind in the cirques and valleys. The depressed areas were occupied by chains of lakes. In places, morainal debris formed a stair-step series of little basins. In the basins, moraine deposits can be recognized by hummocky terrain.

B. Soil Development

Quartzite is very resistant to weathering. Where it makes up the principal parent material, soil development is a slow process at best. When combined with the low temperatures and short summers common to the alpine climate, there is little wonder that the soils of the alpine portion of the Uinta Mountains are generally shallow and stony. However, where thin shale layers are exposed they contribute beyond their relative bulk in soil building materials.

Fig. 1 - Looking west along the main axis of the Uinta Mountains. The peaks in the background represent roughly the main axis of the anticlinal fold.

Fig. 2 - Weathering has broken up the exposed quartzite to form vast boulder fields throughout the alpine area.

One of the early invaders of these boulder fields is Geum rossii. Here this plant is forming small colonies throughout the rock field area. Before this plant can become established soil materials must accumulate near enough to the surface for the plants to become established. Thereafter, the plants themselves aid in the soil-building process.

Cox (1933) in discussing soils of the James Peak area of Colorado said that alpine soils are generally characterized by their stony, gravelly nature, strong acidity, and heavy leaching. He also showed that lack of stability, except on moderate slopes, prevents the development to maturity of alpine soils. However, the alpine soils of the Uinta Mountains are not all shallow and poorly developed. In some of the more favorable sites, moderately deep, moderately developed soils are found.

1. Agents of Soil Formation

a. On-site weathering

Due to the low temperatures of alpine areas, chemical action is held to a minimum. Consequently, most of the breakdown of the parent material is due to mechanical disintegration or through deposition by wind. Agents of disintegration important in the alpine area are ice (formerly as glaciers), wind, rapid changes in temperature, freezing and thawing of water, grinding action of stone heaps in talus slopes and stone glaciers (gravity), and the action of plants.

b. On-site accumulation of soil material

Loess deposits apparently have been a source of soil-building materials. The silt loam surface horizon so common over much of the area gives strong indications of wind deposition. Also soil materials accumulate by glacial and peri-glacial phenomena, alluvial, and colluvial action--possibly some buried soils.

2. Soil Development Sites

Soil development on six major kinds of sites was observed. The findings on these sites are correlated with major plant communities which are treated later in the report.

a. Glacial moraines

Glaciation in the Uinta Mountains was principally by valley glaciers. The broad drainage heads within the alpine zone were formed as a result of nivation and glacial scour. Most of the transported material was deposited as moraines in areas now occupied by spruce and lodgepole forests. As the ice retreated after the glacial period, some scattered drift, in the form of ground and lateral moraines, was left in the high alpine basins (Atwood, 1909). The soil-building materials of the glacial deposits are an unsorted mixture ranging from clay to boulders.

As the glaciers melted, the snow accumulation areas in the high alpine basins were last to become snow-free; as a consequence, the soils are younger and generally lack in development when compared with areas extending above the ice. Soils on the glacial deposits are shallow and rocky, generally having less than a foot of solum and often consisting of 50 percent or more of stones.

b. <u>Fellfields</u> (ridges above timberline)

Fellfield is defined as a treeless, rock-strewn area, above timberline or in frigid zones, dominated by low plants or by grasses and sedges. This definition could apply to most of the area above timberline. In this report, however, it includes only the areas where very little soil has developed, like on exposed ridges and passes. It does not include meadows, boulder fields, loessal deposits, or the glacial deposits. Pebble mulches are often characteristic of these areas.

Soils of the fellfield are very shallow and poorly developed because of the harsh climate common to these sites. Fellfield areas in general are not covered with glacial ice; consequently, they are relatively old in relation to the basins and other glaciated areas. Of all the alpine soil sites checked, these come the closest to being a residual soil.

c. <u>Boulder fields and talus</u>

Boulder fields are very prevalent in the Uinta alpine. In the process of soil development the boulders are gradually buried. The portions of the boulder field in the more favorable sites, such as on moderate slopes and less exposed areas becomes buried first. There are still vast areas of the boulder fields and talus slopes where little or no soil buildup has taken place. Observations in boulder fields show that soil first develops in small pockets. These small pockets, under the protection of early invading plants, eventually grow into islands and, with continued soil accumulation, the islands grow and eventually coalesce, resulting in a continuous soil cover with occasional projecting boulders. In some areas, so-called rock channels remain. Both Murdock (1950) and Hayward (1952) discussed rock channels. Hayward said, "The persistent rocks may be attributed in part to a lack of time for the climax community to spread a continuous blanket over the original substratum, but their persistency is also associated with the action of water. On the slopes, they serve as runoff channels from melting snow and summer rains, and on the level ground, they remain filled for varying lengths of time with standing water, forming temporary ponds." Some of these "rock channels" can be attributed to frost sorting resulting in such features as "stone nets" and

stone stripes (see section C.2. of this report). Figures 2, 3, and 4 show stages of development of soil and plant communities in the boulder field.

Some of the deeper alpine soils were found in boulder field sites. These were well drained soils of medium depth. The sedge-grass plant community was characteristic of the better soils. This is in agreement with Bliss (1956). In his studies on the Snowy Range of Wyoming, he found that both soil and plant communities reached their best development and greatest maturity on the fairly level, well drained sites. Where site studies have been run on the boulder field sites, soils with depths up to 30 inches were observed. Murdock (1950), in digging in similar sites, found soils up to four feet in depth. These better boulder field soils were of medium texture with moderately developed B_2 horizons.

Most of the area occupied by boulder fields, like those of the fellfield, was above the glacial ice and, therefore, relatively old in relation to other Uinta alpine soils. However, those developed from loess may be younger. Much of the wind-blown material was probably deposited at the close of the last glacial period, but is still continuing as dust storms periodically deposit new materials on the mountain.

d. Alluvial outwash (below boulders or talus)

One of the most active soil development sites on the Uinta alpine is on the alluvial terraces. Terraces and fans are found at the foot of boulder fields and talus slopes. Soils on these sites are formed from the fines flushed out of the boulder fields and talus slopes by snowmelt and summer storms.

Each season during high runoff periods these deposits are subject to modification. There may be deposition in one spot and cutting in others. Figure 5 shows early plant invasion on a recent deposit. In Figure 6, there is a buildup of alluvial materials along a small stream. Figure 7 indicates the lack of soil stability of the alluvial deposits. In Figure 6, there is a buildup of soil materials, while in Figures 7 and 8, soil is being removed from a formerly stabilized area.

On recent deposits where colonies of Geum were becoming established, little or no soil profile development was observed. The soils were an undifferentiated mass of gravelly, sandy loams (see Figure 5). On portions of the same terrace, however, well-developed plant communities were found. Here, the soil profile exhibited the same high degree of development as the productive plant community growing on it (Figure 9).

Soils in excess of 30 inches were observed on alluvial terraces where the deepest soils of the alpine area are generally found.

Fig.3 - A medial stage of soil and vegetation development on a boulder field. However, frost sorting activity is also evident. Geum rossii is the dominant plant around the periphery of the soil islands where it continues to invade further into the boulder field. The Carex rupestris-Geum rossii community occupies the centers of the soil islands. Other important species are Agropyron scribneri, Potentilla spp., Erigeron sp., Paronychia pulvinata, Trifolium dasyphyllum, Selaginella densa, Silene acaulis, and Hymenoxys grandiflora. Species like Kobresia myosuroides and Carex elynoides were found near the center of the larger soil islands.

Fig. 4 - A late stage in the soil and vegetation development of a boulder field. Only occasional boulders protrude above the soil surface. Here, the soils are of medium depth and moderate development.

Kobresia myosuroides is dominant in this community and makes up over half of the herbaceous production. Geum rossii ranks second in importance and is most conspicuous around the protruding boulders. Other species common to the site are Deschampsia caespitosa, Polygonum bistortoides, Carex pseudoscirpoidea, Hymenoxys grandiflora, Carex alba-nigra, and Artemisia scopulorum. Herbage production was approximately 750 pounds per acre, dryweight.

Condition classification excellent.

Fig. 5 - Colonies of Geum rossii on gravel alluvial terrace, at the foot of a talus slope. This is the early stage of development on such sites. Small clumps of Carex tolmiei can also be noted between the Geum colonies. The soil under this colony stage of plant development is a poorly developed, gravelly, sandy loam.

Fig. 6 - Soil deposition at the base of talus and boulder fields. The streambed of this small stream is 12 inches above the surrounding area. A small alluvial fan is being built as a result. Plant communities grade from the *Carex aquatilis* meadow adjacent to the stream to *Deschampsia caespitosa* on the damp meadow edge and eventually to sedge-*Geum* communities on well-drained portions of the alluvial fan.

Fig. 7 - This area receives a considerable amount of drainage water during spring snowmelt periods. The soil strip in the center of the photo is being eroded on the edges despite the 100 percent ground cover of excellent vegetation on the bulk of the strip. There is a question as to the originating cause of the soil erosion taking place on this soil strip. Lateral cutting will probably continue until removal is complete.

Fig. 8 - A broad drainageway below a large snowbank area extends through the center of the bench in the foreground. Note the bank cutting and pocketing along the edges. The Krumholtz spruce (circled) is about six feet from a cutting bank and on the same level as the drainageway. Ring counts showed the spruce to be over 60 years old. This indicates bank cutting is a slow process in the alpine turf.

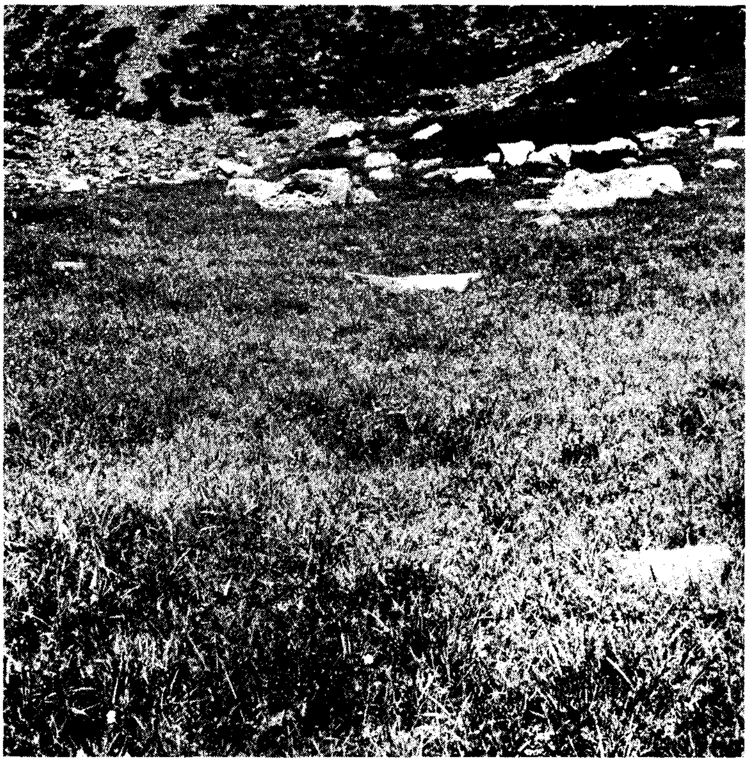


Fig. 9 - The Geum rossii-Carex tolmiei plant community has developed on an alluvial outwash flat. This is a stabilized area south of the area shown in Fig. 5. Geum rossii and Carex tolmiei make up 85 percent of the vegetation. Other species are Festuca ovina brachyphylla, Poa spp. Deschampsia caespitosa, Plantago tweedyi, Artemisia scopulorum, Polygonum bistortoides, and Potentilla sp. Herbage production was 884 pounds per acre, dryweight. Range condition is good for vegetation and excellent for soil.

The soil is a moderately deep loam that grades into a gravelly loam. It also has a moderately developed B_2 horizon in contrast to the poorly developed soil in Fig. 5.

e. Slopes below seeps and snowdrifts

Slopes develop on rather steep slopes where a continuous summer supply of moisture is available. Soil development is common along small streams originating at snowbanks or sidehill seeps. Soils first form along the stream course, and meadow plants form the main vegetation. As soils build up and the stream is diverted, species of plants common to well drained sites occupy most of the soil strip. As the soil and vegetation cover develop simultaneously, good soils may result on many of the sites.

Soil development on this site is comparable to that of the boulder field and streamside meadow.

f. Meadows and bottom lands

Erosion processes, both natural and induced, concentrate sediment in the low spots such as lake basins, drainage channels, and depressions. Water also accumulates on the same low areas. The sediment provides a good supply of soil-building materials, but the drainage is generally poor, and results in the development of meadow and bog soils. These wetland soils are highly varied. All gradations of soil can be found from the peat-muck soils of the bogs to the well-developed, highly organic soils of the dry meadows.

Peat-muck soils are found in old lake beds or around the edges of present lakes. Often, these soils are very deep and show considerable peat development. They are characterized by layers of peat and muck over a structureless, blue-green often mottled substrata--all indicating a poorly drained soil. Coarse sedge grows on these soils and may produce as much as two tons of air-dry herbage per acre.

Meadows also develop on topographic positions other than around lakes or old lake beds. Where there is a continuous water supply from seeps or streams, a meadow type develops. Poor drainage conditions may result in a gley soil; however, this is not always the case. Many of these meadows are well irrigated, but the soils have the characteristics of better drained sites. The surface soil is characterized by high organic content. Bliss (1956) found a loss on ignition of 59 percent by weight in the surface layer of alpine meadows in Wyoming.

C. Soil Stability

Alpine soils develop in a severe climate and are continually subjected to all the rigors of that climate. Many alpine soils of the Uinta alpine are remarkably resistant to erosion (see Fig. 10). The tough sod and high organic content of the surface soil, plus a high percentage of gravel and stones, make these alpine soils highly resistant to the erosive action of water and wind.

Where erosion does occur it is generally of moderate or less intensity. This is particularly true of the south slope of the mountains. Gullies

are not common, but some large ones do occur in some of the steeper canyon heads of the north slope. The main indicators of soil erosion are bank cutting (mainly in the deeper alluvial soils), sheet erosion where the turf has been damaged, and sediment deposits in lakes.

Most of the lakes observed did not show signs of excessive recent deposition, although occasionally a lake was found where heavy deposits were observed. Figure 11 shows a lake that has been nearly cut in two by the delta of an intermittent stream. The drainage originates on the heavily grazed Kabell Ridge.

1. Factors Influencing Soil Stability

Soil scientists list four primary factors that influence soil erosion: (1) climate, (2) inherent character of the soil, (3) topography, and (4) retardants, such as vegetation. Man has very little influence over the first three factors, but he plays a dominant role in changing the vegetation.

a. Climate

Weather records of the alpine are only fragmentary, however, it is evident that the alpine has the most rigorous climate of all mountain rangelands. It is an area of extremes in temperature, humidity, and wind effects. In many ways, the alpine climate is more severe than that of the arctic.

Annual precipitation on the alpine portion of the Uinta Mountains is estimated to vary between 35 and 50 inches. Three-fourths of this moisture comes in the form of snow. Due to winds and topography, the total moisture varies from site to site. On lee slopes, deep snowdrifts are characteristic while ridgetops and peaks often are bare. Snow distribution is a big factor in alpine plant community distribution. Recent snowfield studies in Norway have shown this relationship (citation by Johnson and Billings, 1962).

Estimates, based on records from Montana and Colorado, indicate that summer storms furnish about one-fourth of the annual precipitation in the alpine. Johnson (1962), in his study of the Beartooth Plateau, found variations from .31 to .59 inch per week. Nine years of records at Corona, Colorado, (11,600 feet elevation) showed 1.63 inches in June, 2.64 inches in July, and 2.24 inches in August (Retzer 1962). A similar summer precipitation pattern is thought to exist on the Uinta Mountains. Observations during the eight years of study have shown some summers to be very dry with periods of ten days or more with no rainfall. Other summers may have rain or hail every day. Many of the summer storms are heavy and may be accompanied by high winds.

Fig. 10 - Rapid melting after a late June snowstorm, base of Leidy Peak, Uinta Mountains.

This 5-inch snow cover melted in about half a day. With this rate of melt the soil percolation rate was not great enough to take care of the water; as a consequence, much of it ran over the surface. Little or no eroding action was observed. The water was running clear as it left this 10 to 15 percent slope.

Fig. 11 - A sand delta extending into a small lake, head of Burnt Fork, near Bennion Lake, Uinta Mountains. Runoff from the ridge above has washed material into this lake. The ridge is a heavily grazed area.

If the average annual precipitation is 40 inches in the Uinta alpine zone, the 250,000 acres within this zone must dispose of 832,000 acre-feet of water annually. With the relatively shallow soils and low vegetation of the alpine zone, the probability is that much less of this water is held and used on the site than would be the case in the lower timbered zones. Observation during snowmelt and during summer storms, plus indicators on the ground, show that a large portion of the precipitation leaves the area as surface runoff. "Washout" pockets are evident in the heavy turf, particularly below "boulder field" slopes where the water runs over the turf.

Average annual temperatures in the alpine, where records are available, are under 30 degrees F. A nine-year record in Colorado (Corona) averaged 27.9 degrees F. Here, December was the coldest month with an average of 9.4 degrees F., the warmest month had an average of 48.8 degrees F. Summer temperatures were very comparable on the Beartooth Plateau (Johnson 1962). Average temperatures varied from 46.4 degrees to 48.3 degrees F. during the study period of three years.

Frosts are frequent on many alpine sites during the growing season. Summer temperature records from eight study sites made by Johnson and Billings (1962), during their study of the Beartooth Plateau, showed an average of 48 percent frost-free days. This percentage varied from 82 percent on a ridge site where air drainage was good to 29 percent on the _Carex-Eriophorum_ meadow.

During the summer season, winds are usually light to moderate during the day and calm at night (Hayward 1952). Johnson (1962) estimated the average wind velocity as 9 mph in July to 17 mph in January on the Beartooth Plateau. On the Uinta Mountains, strong winds of several days' duration may occur at times during the summer. Winds of 40 to 50 miles per hour are not uncommon (Hayward 1952). Retzer (1962) cited winds of 160 mph on Pikes Peak in Colorado.

Hayward (1952), in discussing the Uinta Mountains, said that relative humidity usually varies from 35 to 75 percent. However, it may drop to near 10 percent during the daytime during periods of clear weather.

b. Soil erodibility

Several methods have been used to appraise the erosion resistance of a soil. A recent approach is to represent this resistance as an "erodibility index." The two soil characteristics used in determining this index are surface aggregate detachability and profile permeability. These two characteristics are assigned numerical ratings, the product of which gives the erodibility index.

Soil granules must be detached before they can be transported by water; therefore, strength and size of the surface aggregates determine the detachability of the soil granules.

Profile permeability of a soil is dependent upon the surface texture, soil depth, and the presence or absence of obstructing layers, such as clay or solid bedrock.

Alpine soils of the Uinta Mountains are generally of medium texture, varying from sandy loams to silt loams in the surface horizon. The surface aggregates of these soils are rather weak and poorly defined. Soil depths vary from very shallow to medium (generally 12 to 30 inches). Development of the "B" horizon is slight to medium. Gravel and stoniness characterize many of the alpine soils. As a result of the combination of these characters, the erodibility index generally falls in the medium classification. In other words, characters favoring erosion are just about balanced by those characters that resist erosion. Light to medium soils have a high infiltration rate, yet the soil aggregates are generally weak, which subjects them to a high degree of detachability. Soils are generally shallow which limits their water storage capacity, yet many have little or no restricting layers to reduce their permeability. Stones and gravel may also be present to aid in holding the soil in place.

An exception to this general rule is found in the areas of shale-derived soils which are very unstable although rather limited in extent (Fig. 30). Their "erodibility index" varies from moderately high to high. Rapid erosion is taking place wherever these soils do not have adequate ground cover. Any grazing use that damages the plant cover may have serious consequences on these areas.

c. Topography

Topography, as it affects the erosion hazard, is primarily a factor of slope. Slope increases the velocity of running water which increases its erosive power. Range allotment analysis data from the Wasatch National Forest showed a rather strong correlation between degree of slope and range condition when soil stability was used as a basis for range condition.

Most of the range portion of the Uinta alpine has rather gentle topography. The forage-producing areas are found in the broad basins, on terraces, and on broad ridgetops. It is only under special situations that soils have been able to develop on the steeper sites. Most of these steep areas are covered with talus or are exposed bedrock.

d. Ground cover (vegetation, litter, and naturally occurring rock)

Through the study of relic or lightly grazed areas, a number of characteristics were observed in the Uinta alpine area. First, observations on stable sites show that ground cover is nearly complete; that is, vegetation, litter, and naturally occurring surface rock, where present, give the soil almost complete protection. Even on very rocky areas, very little soil is exposed. Second, the vegetation is naturally very short. In the cushion plant communities, the vegetation may be less than two inches in height. The average alpine turf does not exceed four inches, except in protected spots. Third, most of the alpine plant communities have a very tough sod, generally about six inches thick. The numerous roots, plus the organic matter, may constitute over 50 percent of the top layer of soil. This tough sod gives the alpine turf its stability, despite the rigorous climatic conditions and the medium erodibility index. Fourth, natural climatic action is keeping many sites in an unstable condition, particularly on steeper slopes and in the transition zones between the raw rock and stabilized areas.

The soil stability phase of range condition classification is based upon the amount of ground cover present and upon the degree of erosion. Reduction of ground cover and the resulting breakup of the sod are the "earmarks" of changes in condition. When the ground cover deteriorates due to excessive grazing, the results are reflected in loss of vigor in the forage plants and thinning or "wearing out" of the turf. Weakly anchored plants, such as mosses and *Selaginella*, are easily damaged by trampling and their removal leaves areas of bare soil.

2. Cryopedogenic Features

Cryopedogenic features are the result of frost action on the soils with indirect effects on vegetation. These features are common, but not extensive, on Uinta alpine areas and are characterized by frost hummocks, frost boils, stone nets, stone stripes, and solifluction terraces. All of these features leave their characteristic pattern on the ground and vegetation. Most of them are associated with a breakdown in soil stability, particularly when in their active stages. Instability is obviously accelerated by grazing animals, and it is often difficult to separate the basic causes. In range analysis, no attempt is made to identify the causes, but only to point out and classify the degree of instability. If a site is naturally unstable, it would be folly to add the burden of grazing use to it. Any process or activity that breaks the sod and exposes bare soil also accelerates the frost action. Vegetation and accumulated organic matter form an insulating layer which slows down heat loss and minimizes frost penetration.

a. Frost hummocks

Frost hummocks develop as a result of frost thrusting. They are associated with damp or wet sites where the water table is perched on a silty or clayey layer for at least the early part of the summer season. Hummocks vary in size from a few inches to several feet in diameter and to over three feet in height.

Billings and Mooney (1959), in their studies on the Medicine Bow Mountains of Wyoming, suggested that frost hummocks (peat hummocks) were the first stage in a degradation cycle through frost scars to sorted polygons. In this process, the apex of the hummock is broken and the center eroded away.

Intermixed frost hummocks and frost scars were observed in the Uinta alpine areas (Figures 12 and 13). Sheep trampling was observed on the broken mounds. This probably enlarges the breaks and prevents healing.

b. Frost boils

Frost boils are areas of bare soil where the light-colored subsoil has been thrust to the surface by frost action. They generally vary from two to four feet in diameter. Like the frost hummocks, they are found on gentle topography and on sites having perched water tables on silty or clayey horizons at shallow depths. As long as these frost boils are active, the frost churning prevents the establishment of plant colonies. However, as they become inactive, plants will eventually invade the bare areas. Johnson (1962) found *Stellaria umbellata*, *Trifolium parryi*, and *Salix anglorum* to be the early invaders on frost boils (Fig. 14).

c. Stone nets

In the Uintas, stone nets have been observed on both well-drained and relatively wet sites. Stone nets on the dry sites appear to be inactive, whereas those on the wetter sites show evidence of recent activity. There is a strong possibility that the stone nets on dry sites date back to a time of periglacial activity. Soil adjacent to and beneath the stone nets showed a rather strongly developed soil profile (silt loam "A" horizon over a silty clay loam "B" horizon). A soil trench dug through a stone net indicated comparable profile development under the soil net as was found in the adjacent tundra. This soil development indicates a considerable period of stability.

Studies on the Beartooth Plateau showed no evidence that the stone nets on summits and ridges are presently active and suggested that these patterns were produced during a period of higher soil moisture which could have been held nearer the surface by permafrost (Johnson and Billings, 1962 - see Fig. 15).

Fig. 12 - Frost hummocks and frost scars in a meadow. As the soil is raised above the general level by the frost, the sod in the center breaks and exposes the soil. Often large areas become bare as a result of this action. Trampling by sheep was observed to increase the size of the sod breaks and thus contribute to the instability.

Deschampsia meadow in fair condition.

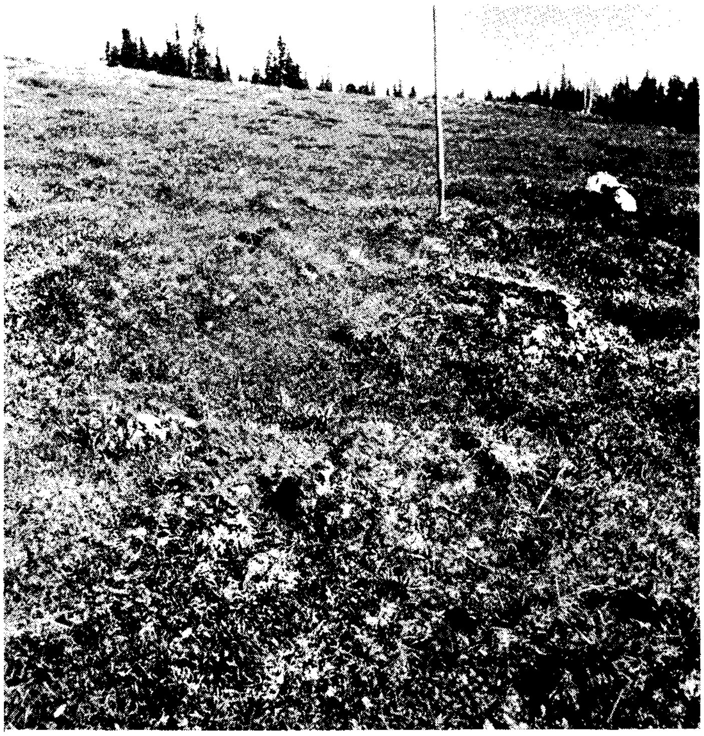


Fig. 13 - Frost hummocks in various stages of their cycle. As a result of frost action subsoil material is forced upwards towards the ground surface forming a hummock. Breaks then occur at the hummock apex and erosion removes the topsoil and light-colored subsoil is exposed. Eventually the entire hummock is removed by erosion and only a bare area or frost boil remains.

Vegetation rating - good.

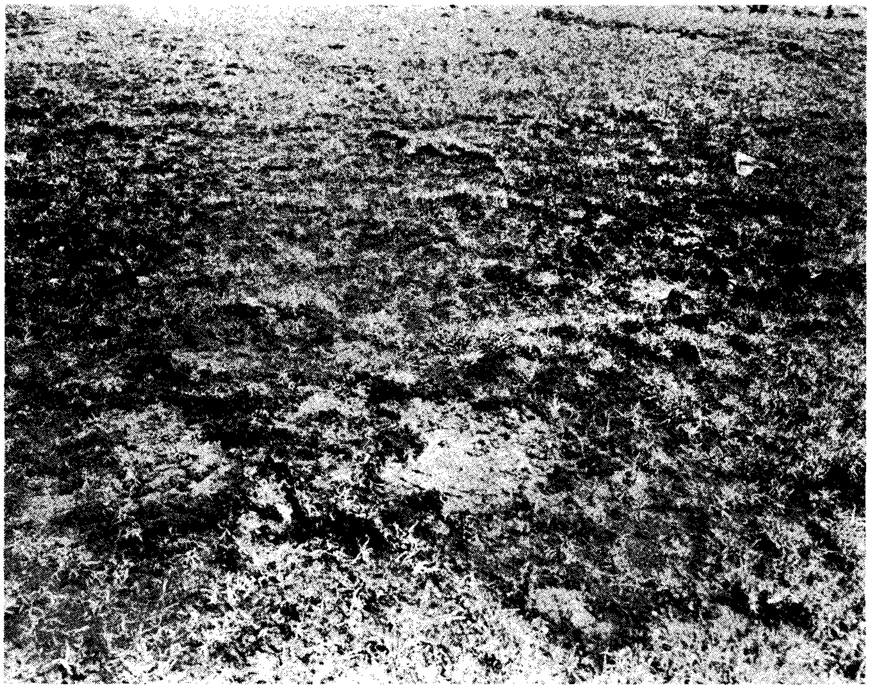


Fig. 14 - Frost and heavy grazing have combined in breaking up the sod in this area. Note the thinness of the vegetal cover. This is the second stage of frost action. The circular cupped-out areas were caused by loss of topsoil.

Dry meadow site in poor condition. Compare with Fig. 13 where the vegetation was rated in good condition.

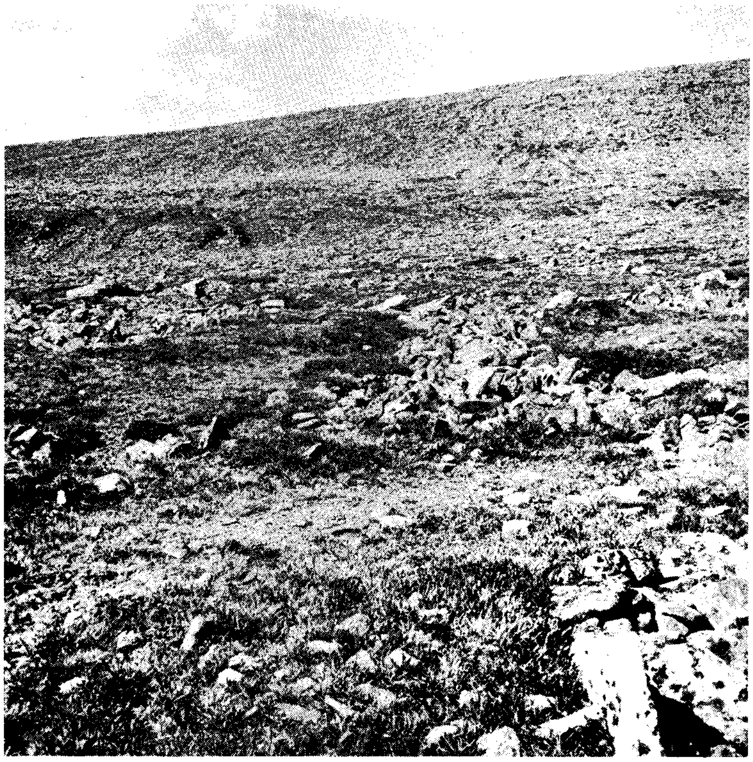


Fig. 15 - Stone nets resulting from frost sorting on an alpine area. This sorting process results from differential movement of stones and fines as a result of frost action. Geum rossii grows vigorously along these stone channels due to additional moisture obtained by extending its roots into the soil under the loose stones.

d. <u>Stone stripes</u>

Stone stripes are similar to stone nets in origin, but have elongated rather than circular patterns.

Investigators feel they are a result of frost heaving on slopes where gravity is a big factor in the sorting process. Johnson and Billings (1962) found that they occurred on lee slopes with gradient of 8° to 18°. Sorted patterns on the Uinta Mountains considered to be stone stripes were found on rather gentle slopes (see Fig. 16.)

e. <u>Solifluction terraces</u>

Solifluction is a mass movement downslope of saturated soil (Johnson, 1962), and is related to the frost patterns in that cungeliturbation (frost action processes) is a factor in its development. As observed on the Uinta Mountains, the terrace faces are generally from one to three feet high. As the soil mass moves downslope, it may override the old soil surface. Sod on the face of the terrace tends to check its movement, but occasionally chunks of sod break loose and fall at the toe of the terrace face.

Solifluction terraces are found on slopes below snowdrifts and seeps. Billings and Mark, in their studies in New Zealand, found that these terraces developed only on slopes of seven degrees or above (Fig. 17).

Sheep, in walking across solifluction terraces, tend to break the sod and thus weaken its stabilizing power on the face of the terrace.

3. <u>Effects of Wind and Surface Water</u>

Wind and running water over the surface also leave their marks on the alpine turf.

As snowmelt water moves off the slopes and out of the boulder fields, much of it runs over the soil surface until it eventually reaches natural drainage channels. Where the concentration of water is great enough, particularly at the base of boulder fields, much gouging of the turf is evident, leaving numerous pockets generally varying from two to six inches deep, but sometimes exceeding a foot in depth. Some head cutting also occurs in drainage channels. Head cutting does not appear to progress very readily because of the tough, tenacious sod.

Wherever the sod is broken, wind becomes a factor in removing soil. Bare areas are enlarged by wind blowing out loose material and tunneling into the turf around the edges of breaks. Retzer (1962) reports large wind-eroded areas in Colorado, concentrated near the ridgetops and heads of major valleys. In these exposed sites where the wind is strongest, any sod break provides a starting point for wind erosion, and may result in the removal of the soil from sizable areas.

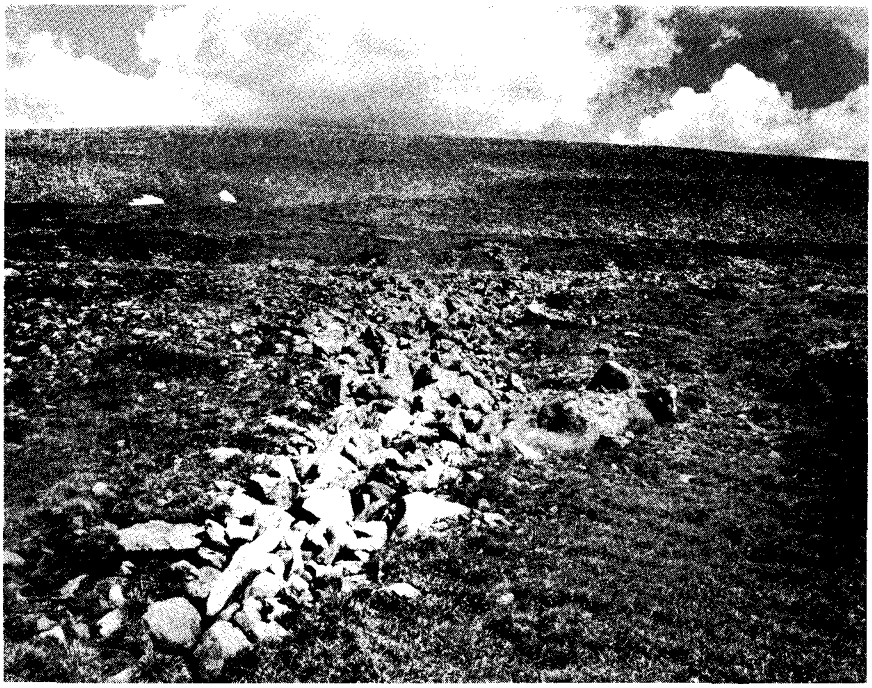


Fig. 16 - A stone stripe. These have similar origin to stone nets. They have elongated patterns rather than circular.

Fig. 17 - Solifluction is common on this slope, showing particularly well on the lower third of the photo. The willows at the crest of the slope indicate a moist condition. Here is a place where the natural soil movement is compounded by grazing use. Sheep trailing across this face have helped break up the sod and it appears that natural healing is being blocked by the trampling on this face. At the time of this photo, the area showed evidence of heavy grazing use.

Where the sod is completely broken, sizable bare areas are beginning to show.

D. Plant Communities

Alpine vegetation is characterized by a patchwork of mixed plant communities. Individual communities may vary from less than a square rod up to several acres in extent. A homogeneous community seldom exceeds 100 acres. The boundaries between the communities vary from abrupt to diffused. The latter is more common and results in much overlapping of the plant communities.

The amount of moisture available during the growing season is the main factor that determines which species will be found on a particular site. Aspect, slope, and wind exposure control the snow distribution, which in turn determines, to a large extent, the plant community that grows on the site. Johnson (1962), in his alpine studies on the Beartooth Plateau, found that depth of winter snow accumulation and time of snowmelt were of great importance in local distribution of alpine species. He classed Deschampsia caespitosa sites as snowbed vegetation. Geum turf characterized the exposed sites where wind removed much of the snow. Water accumulation, due to poor drainage, resulted in such bog vegetation as the Carex scopulorum community. Johnson (1962) also cites the extensive studies made by European investigators Gzaerevoll and Dahl on the influence of snow distribution on alpine plant communities.

In the alpine areas of the Uinta Mountains, 10 to 15 species constitute the bulk of the vegetation cover. Geum rossii is the most common and was found to be dominant or codominant on two-thirds of the sites studied. Carex pseudoscirpoidea was a major constituent of the community on half of the study sites. On the drier, more exposed sites, Carex rupestris is a major species. Deschampsia caespitosa is the characteristic species of dry and wet meadows. Other important species are Trifolium nanum, T. dasyphyllum, Festuca ovina brachyphylla, Antennaria spp., Kobresia myosuroides, Carex elynoides, Polygonum bistortoides, Danthonia intermedia and Poa spp. Carex tolmiei is one of the most important alpine species found on the north slope of the Uintas but has only occasional occurrence on the south slope.

1. Carex rupestris and Cushion Plant Communities

The Carex rupestris and cushion plants occupy the driest, most exposed sites of all the alpine plant communities. They are confined, primarily, to the ridgetops, open passes, and other areas where the soils are shallow. These sites are exposed to the winds so that snow accumulation is greatly reduced (Fig. 18).

The soils on these xeric sites are usually shallow and have a high stone content. Both of these factors are consistent with low water-holding capacity. There are interesting exceptions to the above rules. One Carex rupestris site on a 12,000-foot mountain was found to be of medium depth with moderate soil development. Evidence would indicate that this is an old soil that developed under climatic conditions different from the present.

The cushion plants form the most primitive community and occupy the driest, least developed sites. Griggs (1956) listed Silene acaulis as the most aggressive pioneer in the Rocky Mountain fellfield. Other important pioneer plants are Paronychia pulvinata, Trifolium nanum, and Arenaria obtusiloba. The cushion plant communities are found in small localized areas with a comparatively small acreage.

Carex rupestris is found in various amounts in most of the cushion plant communities. However, on the better sites, it becomes dominant or codominant with the cushion plants. This species also occurs in other alpine communities. Johnson and Billings found the percentage of drummond sedge and Geum rossii to be inversely related on the Beartooth Plateau.

The following species are common in the cushion plant and Carex rupestris communities:

Dominant Plants

Carex rupestris
Silene acaulis and/or Paronychia pulvinata
Trifolium nanum

Other Important Species

Selaginella spp.	Smelowskia calycina
Trifolium dasyphyllum	Lloydia serotina
Festuca ovina brachyphylla	Carex elynoides
Potentilla spp.	Poa rupicola
Arenaria obtusiloba	Trisetum spicatum
A. fendleri	Draba fladnizensis
Helictotrichon mortonianum	Erigeron simplex
Trifolium parryi	Kobresia myosuroides

2. Geum-Sedge and Sedge-Geum Communities

All gradations are found between nearly pure stands of Geum to types with a strong sedge aspect. A large percentage of the alpine range is found within the broad range of these communities (Fig. 19).

Geum rossii has its greatest dominance in the early invasion of boulder fields (Hayward, 1952, and Murdock, 1950). This plant is able to extend its long roots to a considerable depth between the rocks and under the rock channels and stone nets, thus making use of moisture and nutrients that are not available to the shallower-rooted grasses and sedges.

Geum-rossii also extends its dominance into dry meadows in association with Deschampsia caespitosa. Johnson and Billings classified such areas as snowfield communities. As the poorly drained sites are approached, the Geum gives way almost entirely to the Deschampsia.

Fig. 18 - The cushion plant community which is characterized by such low-growing plant forms as Carex rupestris, Silene acaulis, and Paronychia pulvinata. This community is found on the very shallow residual soils and is common on high, exposed ridgetops and passes. Where these sites have not been used excessively for sheep bed grounds, they are generally in good condition. They are not particularly attractive to sheep because of the low forage production. The high stone and gravel content of soils on these sites makes them resistant to damage by livestock.

Condition classification is excellent.

Fig. 19 - Geum-sedge community. The vegetation on this site is principally *Geum rossii* and *Carex rupestris*.

Fig. 20 - Sedge-grass community. This is the nearest approach to climax found on the Uinta Mountains. The dominant species is Kobresia myosuroides. Sedge and grasses make up over three-fourths of the herbage. The soil was of medium depth. The silt loam "A" horizon is 11 inches thick which overlies a 10-inch silty, clay loam "B" horizon. The dryweight herbage production was 726 pounds per acre.

This site was classed in excellent condition.

Major species associated with the Geum are Carex pseudoscirpoidea and Deschampsia caespitosa. The former is often codominant with the Geum in the better drained areas, but is replaced by the Deschampsia as imperfectly drained situations become evident.

Species commonly found in these communities are:

Dominant and Codominant Species

Geum rossii	Carex pseudoscirpoidea
Deschampsia caespitosa	

Other Important Species

Festuca ovina brachyphylla	Potentilla concinaeformis
Danthonia intermedia	P. diversifolia
Artemisia scopulorum	Polygonum bistortoides
Carex rupestris	Sedum stenopetalum
Antennaria spp.	Erigeron spp.
Poa spp.	Trifolium spp.
Kobresia myosuroides	Carex elynoides

3. Sedge-Grass Community

The sedge-grass community, as characterized in this report, is considered as the nearest approach to an alpine climax of any community found in the Uinta Mountains (see Fig. 20). The dominant species is either Kobresia myosuroides or Carex elynoides. It is very difficult to separate these two species in the field as seed heads are usually very scarce for both species, their growth habits are very similar and they occupy a comparable ecologic position. Frequent collections of both species have been made in the alpine portion of the Uinta Mountains. This community has been recognized by various students of alpine flora. Osborn (1959) and Marr (1961) considered Kobresia myosuroides to be the dominant species in certain alpine sites on the Front Range of Colorado. Johnson and Billings (1962) considered Carex elynoides as forming a distinctive community of the Geum turf on the Beartooth Plateau of Wyoming and Montana.

On the Uinta Mountains, the community occurs on the most stable portions of high ridges and slopes and above the areas subjected to glacial action. The soils are generally from 15 to 26 inches in depth and show good development for such high elevations.

Records of transect studies within the community showed considerable variation in the quantity of the different plant constituents. The dominant species determines the aspect and makes up 28 to 55 percent of the composition by weight. Geum rossii is generally present, but in a rather inconspicuous role. Wheatgrass, bluegrass, and other grasses are also common to this community.

The vegetation of this community forms a dense turf. Except for the protruding boulders, it forms practically a complete ground cover. Forage production, depending on the effective depth of soil, varies from 500 to 700 pounds per acre air-dry.

Species common to this community are:

Dominant Species

Carex elynoides or Kobresia myosuroides

Other Important Species

Geum rossii
Festuca ovina brachyphylla
Carex pseudoscirpoidea
Poa spp. (rupicola and lettermani)

Other Species

Agropyron scribneri
A. trachycaulum
Carex alba-nigra
C. phaeocephala
Artemisia scopulorum
Polygonum bistortoides
Erigeron leiomeris
E. simplex
E. melanocephalus
Trisetum spicatum
Carex haydeniana
C. rupestris
Deschampsia caespitosa
Hymenoxys grandiflora
Potentilla diversifolia
Solidago multiradiata
Danthonia intermedia

4. Wet Meadow and Bog Communities

There are a number of wetland situations grouped under the wet meadow classification grazing from bogs in old lakebeds to stringer meadow strips along streams. Characteristic vegetation communities are found on the various wetland sites, depending on the degree of drainage or lack of drainage. Some of the communities are small and insignificant from the range management point of view, and only the more important ones will be discussed.

Many of the wet meadow areas are too wet for sheep grazing and are generally in good to excellent condition.

The Carex aquatilis community is found on the very wet or boggy sites of the wet meadow complex. This community may form the first zone adjacent to open water and may extend into the water for a short distance. It may also extend over the entire area of old lakebeds. Wet peat soils are associated with this community. Species common to the community are:

Dominant Species

Carex aquatilis

Associated Species

Mosses	Eriophorum chamissonis
Carex illota	Caltha leptosepala
C. bipartita	Sedum rhodanthum
Pedicularis groenlandica	Eleocharis pauciflora

Moss fills the interspaces between herbaceous plants, thus forming a complete ground cover of vegetation.

Carex saxatilis Community

Hayward (1952) based his wet meadow classification on this community. Recent field checks have shown it to be one of numerous meadow communities. It was found to be mostly in intermittent ponds and lakes and in areas gouged out in other communities by heavy runoff. This sedge is tolerant to relatively deep standing water for part of the season. Nearly pure stands of Carex saxatilis var. major are common to many sites or it may be associated with such species as Juncus albescens, J. mertensianus, Deschampsia caespitosa, Carex nelsonii, C. nigricans, and Eriophorum chamissonis. Often clumps of Salix are also found within the community. Many of these associated species grow on raised hummocks within the Carex saxatilis community.

Deschampsia caespitosa Community

This is the most extensive community of the wet meadow complex (see Fig. 21). Moisture supply is adequate throughout the season and only excessive in the spring. Soil profiles generally show some mottling which indicates a degree of imperfect drainage. This community often forms the intermediate zone between the Carex aquatilis community and the dry meadow, or forms narrow borders along alpine streams.

Species common to the community are:

Carex ebenea	Potentilla diversifolia
C. bipartita austromontana	Juncus albescens
C. illota	J. drummondii
C. nelsonii	Eleocharis pauciflora
C. bigelovii	Pedicularis groenlandica
C. nigricans	Gentiana spp.
C. media	Polygonum bistortoides
Phleum alpinum	

Salix colonies are also found associated with this community (Salix planifolia, S. drummondiana and others).

Fig. 21 - Wet meadow in excellent condition. Adjacent to open water - Carex aquatilis.

Bulk of wet meadow - Deschampsia caespitosa community.

Associated species - Carex ebenea, Caltha leptosepala, Phleum alpinum, Pedicularis groendlandica, two species of moss, Sedum rhodanthum, two species of Gentiana, Potentilla sp., Polygonum bistortoides with colonies of Salix.

Wet meadow edge - Antennaria sp. Castilleja sp. with Juncus drummondii.

Cupped-out areas in meadows - Carex saxatilis major.

The estimated dryweight production was 850 pounds per acre.

5. Dry Meadow or Deschampsia-Geum Community

Separation of dry meadows from closely related types and subtypes may be rather difficult. The dry meadow community grades gradually from wet and semiwet meadows and merges with the dryland communities. It is closely associated with the *Deschampsia caespitosa* community, but is drier and the associated species are different (Fig. 22). Soil moisture is plentiful early in the summer season but may be lacking by late summer. Soils are relatively deep but fairly well drained. Positioned in the basins and at the foot of slopes, the dry meadow community is supplied with moisture from adjacent areas.

Common to the dry meadow community is a mixture of species from the wetter and drier alpine sites. The two most important species are *Deschampsia caespitosa* and *Geum rossii*. On range in good or excellent condition, *Deschampsia* is the dominant plant. *Polygonum bistortoides* and *Carex pseudoscirpoidea* also may be common in the type.

The dry meadow community is rather common on the Uinta alpine areas, is a favorite of grazing animals, and heavy use and damage to the plant cover have occurred in many areas.

The following species are common to the *Deschampsia-Geum* community:

Dominant Species

Deschampsia caespitosa

Most Important Associated Species

Geum rossii	Carex pseudoscirpoidea
Polygonum bistortoides	

Other Important Species

Festuca ovina brachyphylla	Danthonia intermedia
Trisetum spicatum	Poa leptocoma
Potentilla spp.	Juncus drummondii
Trifolium parryi	Luzula spicata
Artemisia scopulorum	Trifolium dasyphyllum
Sedum stenopetalum	Erigeron peregrinus
Antennaria corymbosa	E. simplex
Lewisia pygmaea	Eritrichium nanum elongatum
Saxifraga rhomboidea	Sibbaldia procumbens
Silene acaulis	Stellaria longipes

6. Alpine Shrub Community

Shrub communities of the alpine area of the Uinta Mountains are the willow, dryad, and alpine heath. Only the willow-field community is large enough in area to be important to grazing management. The taller species of willow ordinarily occur as small colonies in meadows, along streams, and around lakes, occasionally forming willow fields.

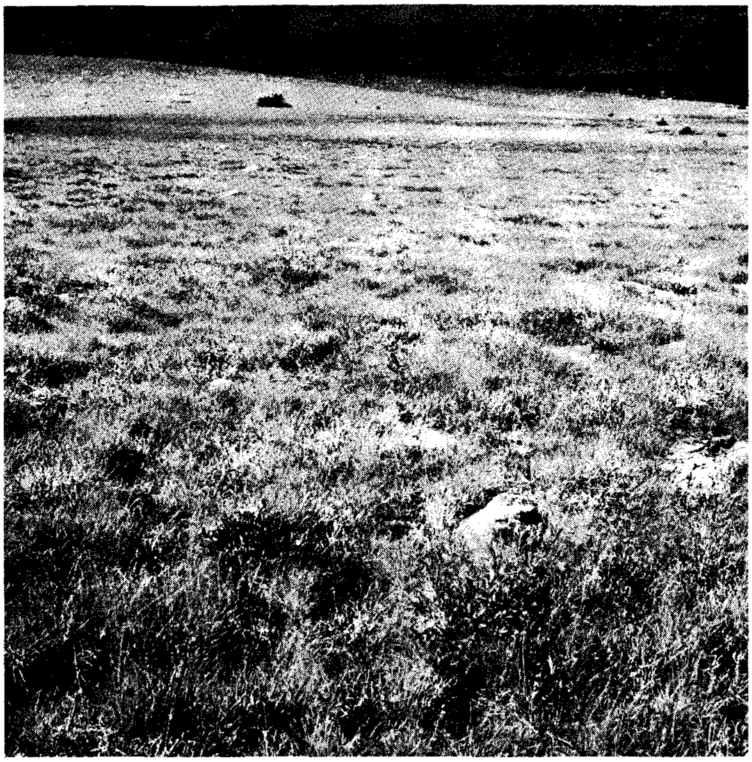


Fig. 22 - Dry meadow. The important species in this community are Deschampsia caespitosa, Geum rossii, and Carex pseudoscirpoidea.

The taller species of willow range from two to four feet in height and include such species as Salix planifolia, S. glauca glabrascens and S. drummondiana. Associated with taller willows are the grasses and sedges common to the meadow communities (Fig. 23).

Sheep grazing has been very damaging to some species of willow. Hedged and dead willow clumps are common on heavily grazed ranges.

Willows are quite susceptible to wind and snow blast damage, and exposed twigs may be killed back as much as six inches.

The dwarf willow clumps are too small to be given much consideration in vegetation classification. They occur in colonies of only a few feet in diameter. Three species of dwarf willow found in the Uinta Mountains are Salix nivalis var. saximontana, S. cascadensis, and S. anglorum var. antiplasta (Fig. 24). The latter, which is known as the rock willow, is found on rocky slopes.

Another low alpine shrub found on the High Uintas is the dryad or Dryas octopetala. This species, like the dwarf willow, forms only small colonies. It is more commonly found on the north and east slopes of ridges.

Alpine heath are infrequent on the Uintas. They either form small colonies within the major types and communities or the plants are associated with the sedges and forbs as a part of the community. Vaccinium caespitosum and V. scoparium, which are common to the conifer zone, extend into the lower portions of the alpine zone where they occur in meadow communities. Kalmia polifolia and Gaultheria humifusa are found occasionally along the borders of lakes and streams and in rock fields.

7. Conifer Community

Only the upper edge of the spruce forest adjacent to the alpine zone is considered in this report. Scattered trees and open parks characterize this community (Fig. 25). It extends into the heads of drainages and along terraces and benches, often extending to the base of the peaks. The drier sites within this area are generally in poor condition due to heavy grazing. The conifer community is one of the heaviest grazed portions of all the high elevation types.

The understory vegetation of this type consists of a mixture of alpine and spruce zone species. The vegetation varies from two to three inches in height and production is generally between 300 and 400 pounds per acre dry weight. Under protection, the production may approach 500 pounds. The soils of this type are highly acidic which probably restricts the production of herbaceous vegetation.

Fig. 23 - Alpine-shrub community. This willow type is closely associated with the meadow communities. The planeleaf willow (Salix planifolia) is one of the most common species found in the alpine area.

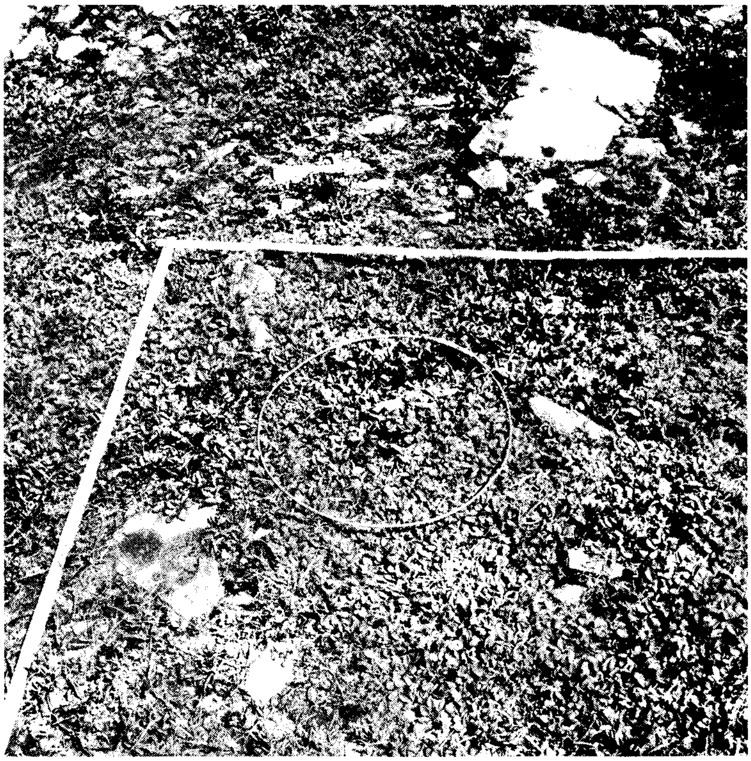


Fig. 24 - Alpine dwarf willow community.

The dwarf willow (Salix nivalis saximontana) makes up most of the herbage in this site on the west terrace of Bald Mountain. Associated species are Carex rupestris, Festuca ovina brachyphylla, Danthonia intermedia, Smelowskia calycina, Potentilla diversifolius, and Artemisia scopulorum.

The soil in this site is receiving protection from a 95 percent ground cover. The rock present is a normal part of the cover and is covered with lichens.

Fig. 25 - Open timberline spruce community.

This is one of the heaviest used types of the high elevation range. Utilization studies and pellet group counts showed that this area was being grazed by sheep at a rate of 70 sheep days per acre. The low vigor of the vegetation reflects this heavy use.

Highly acid subsoil may also be a contributing factor to the low forage production.

Herbaceous species common to the upper-elevation spruce forests are:

Most Common Species

Deschampsia caespitosa	Lewisia pygmaea
Carex pseudoscirpoidea	Sibbaldia procumbens

Other Common Species

Achillea millefolium lanulosa	Polemonium pulcherrimum
Agoseris glauca	Polygonum bistortoides
Antennaria spp.	Potentilla glaucophylla
Artemisia scopulorum	Saxifrage rhomboidea
Arenaria spp.	Sedum stenopetalum
Campanula rotundifolia	Selaginella spp.
Danthonia intermedia	Solidago multiradiata
Erigeron spp.	Taraxacum officinale
Luzula spp.	Thlaspi fendleri
Poa alpina	Trifolium parryi
P. nervosa	Trisetum spicatum
Phleum alpinum	

E. Alpine Plant Succession

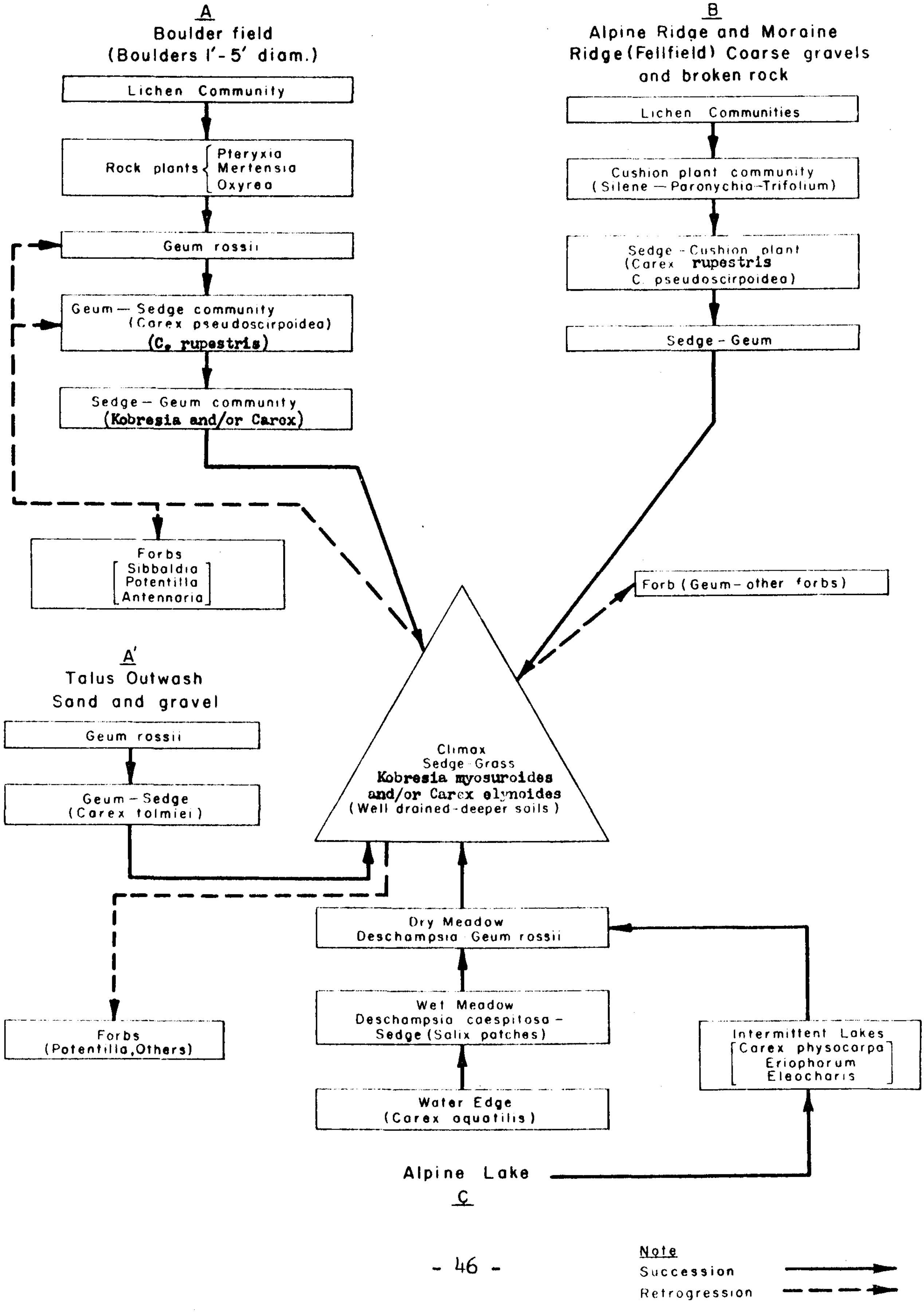
Evidence of three main lines of succession was observed in the alpine zone of the Uinta Mountains (Fig. 26). Two lines of succession start from boulder fields (A) and the fellfield (B). The third line, the hydrarch succession (C), progresses from the alpine lake. Closely associated with the boulder fields are the alluvial deposits at their bases. Here, the plant development on raw alluvium is represented by the line A′. The chart shows all of these lines of succession developing to a sedge-grass climax.

Climax is herein used with reservation. The described communities, rather than replacing one another, may be a reflection of the specific environment. For example, the cushion plant communities may remain as such due to the extremely xeric condition under which they exist, and would change only with a change in environment (climate or geologic). A change in climate would probably explain the medium depth soil under a *Carex rupestris*-cushion plant community on the summit of Leidy Peak. The vegetation appears to be in balance with the climatic factors (moisture and wind), yet the soil reflects a period of more favorable climate on the site.

If any community could be considered climax, the sedge-grass with *Kobresia* or *Carex elynoides* as dominant species would come closest to qualifying. This community is found on the deepest, best-developed soils and on some of the oldest development sites above the reach of heavy glacial action.

ALPINE COMMUNITIES-SUCCESSION AND RETROGRESSION

Fig. 26



The three lines of succession are described as follows:

1. Boulder Field Succession

The boulder field so common to the Uintas is the origin of one of the main lines of plant succession. The boulders, as they appear in fresh talus, present a uniform red hue. With age, the monotonous color of the raw boulders is broken by an array of yellow, green, brown, and black crustose lichens which are the earliest pioneer plants. As little pockets of soil accumulate between the boulders, due to loess deposits and mechanical breakdown of the quartzites, such vascular plants as Pteryxia, Mertensia, and Oxyria become established. One of the early and most important pioneers in the boulder fields is the ubiquitous Geum rossii (Fig. 2). This plant forms the fringe that surrounds the soil islands and progressively invades into the boulder field from all points of its periphery (Murdock 1950, Hayward 1952). This plant is also the dominant species along the edge of rock channels of stone nets. As time progresses and larger islands of soil are formed, sedges and grasses become more important in the mixture and eventually gain dominance. Sedges first to become associated with the Geum were found to be Carex rupestris and C. pseudoscirpoidea.

The Geum-sedge community (principally Carex rupestris) is common to small soil islands and soil centers of stone nets. These sites are dry due to excessive drainage. Much more available moisture is found adjacent to the open boulder fields and along stone channels where vigorous growth of Geum rossii occurs. This plant can send its roots for a considerable distance under the edge of the boulder field and rock channels to obtain additional moisture.

The sedge-grass community occupies the sites where the mantle is more or less continuous or where the soil islands are large. The sedge-grass community is considered to be the highest developed plant community of the alpine area. In this community, Carex elynoides or Kobresia myosuroides may often completely occupy the site to the total exclusion of other species; however, in most cases, Geum rossii is an important associate.

Closely associated with the boulder fields and talus slopes are the alluvial deposits at their bases. A study was made of a talus outwash area in the head of Henry's Fork on the Wasatch Forest. As as result of runoff water flushing finer materials out of a talus slope, a considerable accumulation of sand and fine gravel had been deposited on a terrace.

Geum-rossii and Carex tolmiei were the first important plants to become established on these raw materials. Both spread by vegetative means and colonies of these species eventually invaded the entire area, resulting in a sedge-Geum community. When the community reached an advanced state of development, a large number of species common to the sedge-grass community was found. Plant

succession was reflected in the development of the soil from raw sand and gravel to fairly well developed, moderately deep soil. Figure 5 shows the colony stage and Figure 9 the developed Carex-sedge community.

2. Fellfield Succession

The sites on which the fellfield communities begin are somewhat different than the boulder field. The rock is broken up so there is a mixture of all sizes, from boulders to gravel and sand. A pebble mulch often characterizes the ground surface. The early stage of lichens is found on the rock and may also be found on the gravel where some stability is maintained. Cushion plants are the early invaders of these harsh sites. Soil collects under their spreading mats and eventually covers the rocks and gravel. Such plants as *Silene acaulis*, *Paronychia pulvinata* and *Trifolium nanum* are the most important species in the early stages of vascular plant establishment. An early plant to become associated with the cushion plants and one that eventually becomes dominant in the community is *Carex rupestris*. This stage of development is common in the Uintas. *Geum-rossii* also develops to become a codominant with the sedge. Where soils are able to develop to a sufficient depth, the sedge-grass climax eventually becomes established. Succession on the fellfield sites is very slow because these are some of the harshest sites found in the alpine area. Their usual lack of stability does not allow sufficient soil to develop to support plants of the higher successional stages.

3. Hydrarch Succession (from glacial lakes)

The numerous lakes left by the glaciers have been, or are in the process of being filled with sediment and plant remains. As the filling process advances and the water becomes shallow, meadows are established. Our interest in range classification begins with the wet meadow and not with the successional stages of the lake itself. Many of the shallow lakes have been filled with sediment and have become meadows.

Two main communities are considered here in the successional line. In the wetter portion of the meadow and extending out from the open water is the *Carex aquatilis* community. Standing water is often found over much of the area. Water sedge is dominant on this site and generally makes up a large percentage of the vegetation.

The *Deschampsia caespitosa* community occurs adjacent to the water sedge meadow where excess water is much less prevalent. Drainage is poor and the site remains quite wet throughout the year. It is, however, free from excess surface water much of the season and has a much firmer, less saturated soil than the sedge meadow.

Hayward (1952) based his wet meadow type on *Carex saxatilis*. This plant was found to be dominant in some of the high intermittent lakes and pockets cupped out by heavy runoff, but not an important meadow community.

The dry meadow is the third step in the hydrarch succession. As the water table becomes lower in relation to the soil surface, a different group of species become a part of the plant community. The dry meadow is a meeting place of some of the wetland and mesic species. Deschampsia continues as an important constituent, but dryland sedges and Geum become important associates. With improved drainage, the dry meadow gradually grades into the sedge-grass community.

F. Range Trend

1. Retrogression and Secondary Succession

Outside species are generally not available for invasion into the alpine zone. The climatic restrictions associated with this zone preclude species from the lower zones to a large extent. As a consequence, species present and adapted to the alpine zone have a part in the secondary succession, as well as in the primary. Livestock grazing is the most important factor that causes composition change and, if severe enough, will set the stage for secondary succession to take place. Also, natural processes are continually at work breaking down the vegetal cover. Frost, running water, and wind are the more important ones.

Geum rossii was found to be the most aggressive increaser where vegetation was thinned and also as an active invader of areas. On harsher sites, however, Silene acaulis invades and reinvades. Griggs (1956), in his studies of the fellfield, found Silene the principal invader of areas disturbed by roadbuilding.

There are a number of forbs besides Geum and Silene that increase when the original vegetal cover is thinned out or disturbed. The main ones are Sibbaldia procumbens, Potentilla spp., Antennaria spp., Polygonum bistortoides, Cerastium arvense, Ivesia gordonii, and Erigeron spp. Even Trifolium dasyphyllum and T. parryi thrive best where the grass and sedge species are thinned out. Of the grasses and sedges, Carex pseudoscirpoidea and C. rupestris often increase in the stand when other vegetation is thinned out. Poa alpina is most consistently found in bared areas.

In an area just above timberline, two soil levels were studied as to species composition. The upper level was considered to be the original, while the lower had lost a six-inch top layer through erosion. Thirteen species were listed on the study plot and were classified as follows:

Upper Level Only	Both Levels	Lower Levels Only
Poa spp.	Geum rossii	Achillea lanulosa
Danthonia intermedia	Polygonum bistortoides	Stipa lettermani
Artemisia scopulorum	Carex pseudoscirpoidea	Erigeron simplex
Festuca ovina brachyphylla	Arenaria sp.	Foliose lichen
Agropyron trachycaulum		

2. Rate of Change

Little specific information is available on rates of change (trend) in the alpine rangelands. General observations and comparisons between areas with different grazing histories indicate that the process is slow. However, recent changes in management plus data from an inclosure indicate that considerable change can accrue in a relatively short time. For example, allotments that were rested for two years in succession showed a marked improvement in plant vigor, as was indicated by increase of seedhead production.

The Kidney Lakes exclosure showed some measurable changes after eleven years of protection from grazing by domestic livestock. Besides improvement in plant vigor as reflected in individual plant size, there was some change in plant composition. The more important forage species which were classed as "Desirables," showed an increase from 65 percent of the composition in 1956 to 82 percent in 1967. Carex species showed increases of 20 percent (based on frequency measurements). Polygonum bistortoides, one of the more palatable species, increased from 0 to 10 percent of the plant composition. Sedum stenopetalum, a nonforage species, was reduced from 15 percent to 0. Achillea also showed a decrease from 12 percent to 4 percent. The change in vegetation composition changed the range vegetation condition rating from fair to good.

Part II - Range Analysis and Determination of Grazing Capacity on Alpine Range

The purpose of range analysis is to gather and evaluate data needed to develop allotment management plans which will insure proper management of the range environment to best meet the needs of the resources and the grazing animals. Basic information for developing guides and standards for range classification is assembled in Part I of this report.

Basic steps in range environmental analysis are discussed as follows:

First: Delineation of range types.
Second: Range condition classification.
Third: Determination of suitability.
Fourth: Determination of current and potential forage production.

A. Delineating Vegetation Types

In range environmental work, the vegetation is classed into types. Not all vegetation types are represented on alpine areas. Following are the major range types found on the Uinta alpine:

Type 1 - Grassland
Type 2w - Wet meadow
Type 2d - Dry meadow
Type 3 - Perennial forbs
Type 5 - Browse-shrub
Type 6 - Conifer
Type 7T - Heavy timber
Type 8 - Barren

If scanty or no vegetation is growing in the rock field the area would be classified as 8 (Barren). However, if small patches of herbaceous vegetation occur throughout the type, they should be given a percentage rating and be given a separate classification.

Because of its close relationship to the alpine, the open conifer forest of the upper spruce zone is also described. Here many of the species common to the alpine zone and the forest zone are mixed.

Types may include several plant communities. The major ones are listed under the types.

1. Classification of major plant communities by range types

Type 1 - Grasslands

a. *Carex rupestris* - cushion plant community
b. Sedge-*Geum* community
c. Sedge-grass community

Type 2w - Wet meadow

a. *Carex aquatilis* community
b. *Deschampsia caespitosa* community

Type 2d - Dry meadow

a. *Deschampsia-Geum* community

Type 3 - Perennial forbs

a. Cushion plant community
b. *Geum*-sedge

Type 5 - Shrubs

a. Willow fields

Type 6 - Conifer

a. Upper spruce zone

Types 7 and 8 - Nonrange and barren

B. Range Condition and Basis for its Classification

Condition of alpine range is judged by different standards than most rangelands because it does not follow the usual pattern. Heavy grazing does not change the plant composition to the degree commonly understood and expected on other range areas. Alpine ranges may show damage due to heavy grazing use, yet the plant composition may show very little change. The changes taking place are more of a "wearing out" process wherein the plants are thinned out and reduced in vigor.

Condition guides used for the alpine type are based on the results of site analyses made on areas that have had little or no past grazing use. Most of the sites studied had a ground cover (vegetation plus litter and naturally occurring surface rock) approaching 100 percent. Studies on areas that had deteriorated because of heavy past grazing use showed a marked reduction of ground cover and decline in plant vigor rather than changes in plant composition. Consequently, degree of change in ground cover and herbage production were used as the main criteria for determining range condition. Thus, on most alpine sites in deteriorated condition the soil stability classification will be much lower than the vegetation condition classification.

Guides for rating range condition in the alpine are found in the exhibits at the end of Chapter 40 of the Range Environmental Analysis Handbook. The following guides are used in condition classification:

1. Guide for rating vegetal condition (R-4 Range Environmental Analysis Handbook, Exhibits 41-J and 41-J1).

2. Guide for rating soil stability for alpine types (R-4 Range Environmental Analysis Handbook, Exhibit 41-L, parts I and II).

3. Species list for alpine (R-4 Range Environmental Analysis Handbook, Exhibit 41-I). Many of the foregoing photos in this report illustrate range condition. Many of them show examples of good or excellent condition range because the object of the study was to seek out near-pristine areas to use as a basis for classification. The following photos depict range conditions on a variety of sites:

Fig. 4 - Sedge-Geum community in excellent condition.
Fig. 9 - Geum-sedge community in good to excellent condition.
Fig. 12 - A Deschampsia meadow in fair condition.
Fig. 14 - Dry meadow site in poor condition.
Fig. 18 - Carex-rupestris cushion plant community in excellent condition.
Fig. 20 - Sedge-grass community in excellent condition.
Fig. 21 - Wet meadow (Deschampsia) in excellent condition.
Fig. 22 - Dry meadow in good condition.
Fig. 23 - Alpine-shrub type in good condition.
Figs. 28, 29, and 30 depict different degrees of very poor condition.

C. Guide for Adjusting Herbage Production

From plant development and productivity studies by Billings and Bliss(1959), approximate growth-time curves were developed for well drained sites (ridge above snowbanks) and the imperfectly drained site (below snowbanks), Fig. 27. These two curves should measure the two outside limitations of plant development. The other sites could be fitted in between these two curves as they deviate from one to the other. These curves should give useful guidance in estimating the year's maximum production for all alpine sites.

D. Determination of Suitability

Suitability criteria for alpine range is based on limitations set by one or more of factors such as accessibility, animal preference, soil erodibility, slope, and ground cover. These limitations may be set by the habits of the grazing animals or by the instability of the sites.

Sheep inherently have a preference for certain areas and plants. They will concentrate on some areas and avoid others. Their grazing habits can be learned through studying pellet group distribution or watching them graze. Wet meadows are usually not preferred by sheep but the drier edges around them are. Thick willow patches greatly restrict grazing and may show use only around the periphery of larger patches. If given a choice and not driven, sheep will generally bypass areas containing sparse vegetation.

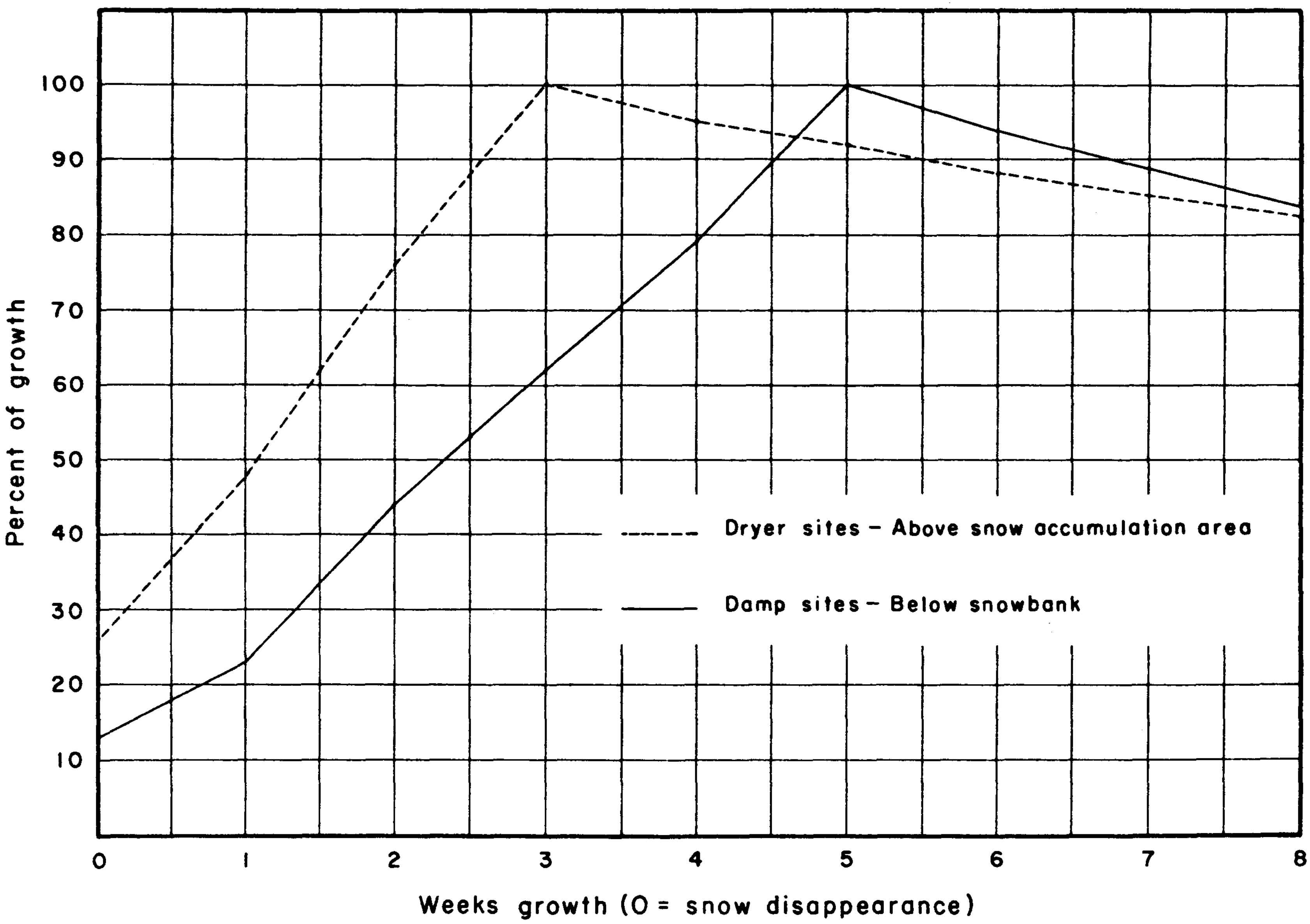
Resistance of soils to erosion, steepness of slope, and the amount of ground cover are factors that must be carefully evaluated in determining range suitability. Soils with a high or moderately high erosion index are very susceptible to erosion. If a protective ground cover of vegetation and litter cannot be maintained under grazing use, the area should

Fig. 28 - Alpine turf in very poor condition. This site has approximately 35 percent bare soil. It is a concentration area with a long history of heavy use. Lack of soil stability places it in the very poor condition class.

Fig. 29 - Geum-sedge community in very poor condition and unsuitable for livestock grazing. The soils on this 40 percent slope are very unstable.

Fig. 30 - Soil from shale parent material is very difficult to manage. Severe erosion is taking place on this site. Such areas are classed in very poor condition and unsuitable for grazing use.

GROWTH CURVES OF ALPINE PLANTS
Figure 27



be classed as unsuitable and closed to livestock use. Soil on shale areas of the Uinta alpine are in this classification. There is much more leeway in managing range with low to medium erodibility indexes. The bulk of the soils in the alpine area are in the medium category.

Slope is a suitability factor involving limitations due to the inverse relationship between degree of slope and stability of the soil and cover. Soils on slopes are generally shallower and solifluction and other sodbreaking activities are more prevalent. Slopes over 20 percent should be heavily sodded before they are considered as suitable for grazing.

Ground cover is one of the most important site factors that determines whether an area should be grazed and/or the degree of use that should be allowed. In the better developed plant communities, observations show grazing use to be a most important factor contributing to reduced ground cover and sodbreaking. Sheep trails cutting through the sod were obvious in the heavily used portions of the range. Site analysis and grazing impact studies indicate that serious erosion problems develop when about 30 percent of the soil becomes bare.

E. Grazing Capacity

Grazing capacity of the alpine ranges depends on the following major factors. First, it must be based on only those areas which have the inherent characteristics to sustain grazing without damaging the resources. Second, the degree of use will depend on current range conditions. Obviously the grazing use on poor condition suitable range should be limited to the extent that the condition will improve. Third, it will depend on the present and potential production capacity of the various sites of suitable range. Fourth, the kind of management system, and the quality of livestock management provided by the grazing permittee will, to a degree, determine the areas that can be used and the intensity of use.

1. Application of the Suitability

Grazing capacity must be based only on suitable range. Where suitable and unsuitable range areas are separate and distinct, management planning can be done with clear-cut decisions. It is where the two are intermixed that careful decisions are required. Much of the alpine range of the Uinta Mountains is in this latter category.

Guides for allowed use of such areas will depend on the damage that will result to the unsuitable portions while the suitable range is being grazed. The damage will generally depend on the basic stability (or lack of stability) of the unsuitable range.

Unsuitable areas on steeper slopes and on shale outcrops must be given full protection from grazing livestock, even though intermingled areas of suitable range remain ungrazed. Also, grazing capacity of adjacent suitable areas will depend on the control that can be given to the grazing livestock.

On areas of moderate topography and where the soils have a high degree of erosion resistance, improved management and light to moderate stocking rates may allow recovery of the sore spots and improve the general range condition. Such range should be classed suitable even though parts of it are in very poor condition.

2. Available Forage

The alpine types are generally low producing areas. The short season, low temperatures, and drying winds all have a tendency to inhibit growth of the inherently low-stature plants of the alpine areas. The plants do, however, make the maximum use of the time and conditions under which they have to grow. Billings and Bliss (1959) found that many of the alpine plants begin growth when temperatures at soil level were near the freezing point of water. They found that species like *Carex elynoides*, *Geum rossii*, and *Deschampsia caespitosa* began growth while still covered with snow.

These same authors found that the plants reached maximum flowering in approximately three weeks after the initiation of growth and matured their seed in seven to eight weeks. A maximum forage crop was produced in three to four weeks followed by a decline (Fig. 27). A number of factors influence the rate and amount of growth made by alpine plants. The major ones are topographic position, aspect, and release date from snow. These factors in turn have major influence on temperature, available moisture, and length of growing season. Studies in the Medicine Bow Mountains of Wyoming showed a production range of 0.6 to 2.3 grams per square meter per day on transects below the snowbank and 0.6 to 1.1 grams per square meter per day on the ridge transect above the snowbank (Billings and Bliss, 1959).

Bliss, (1956) found that under the most severe microclimate of the ridgetop, *Carex rupestris* had an average daily stem elongation of 2.3 cm., while on the south slope, elongation was 5.3 cm.

Bliss (1956) also found that oven-dry plant productions per square meter varied with sites as follows:

	Production	
Location	Grams per sq. meter	Pounds per acre
Ridge	26.7	235
Wet meadow	112.4	1,000
South slope	112.0	1,000
North slope	44.8	400

In this case, the severe ridge site and the north slope were less productive than the meadow. Here, available moisture was the most important factor of production. In the alpine environment, the warmer south slopes were more productive than the north slopes.

Studies of the various alpine plant communities in pristine or near-pristine conditions have given some guides on forage production. Table 1 summarizes the information from 26 site studies made on the Uinta Mountains. Most of these sites were in at least good condition.

Table 1 - SUMMARY OF RANGE SITE STUDIES

Plant Community	Dry Weight Production in Pounds: Total Herbage	Percent Forage	Forage Production	Forage for Use	S.D./A.* 6.6 lbs. Allowance	S.A. per Sheep Month
Carex rupestris	477	68	324	97	14	2.1
Geum-sedge	424	62	263	79	12	2.5
Dry meadow	647	74	479	144	22	1.3
Wet meadow	1283	100	1283	513	77	.38
Carex-Kobresia-Grass	734	87	639	192	29	1.0
Open spruce	350	95	332	100	15	2.0

*The general stocking guides above are based on 40 percent utilization of forage species on wet meadows and 30 percent on the other five communities.

3. Management Systems for the Uinta Alpine

Logistic problems common to the alpine areas of the Uinta Mountains make management supervision very difficult. As a result, planned management has often not received good on-the-ground application. To accomplish an improved and acceptable system of management two points must be considered. First, a system must be developed that is easy for the herder to follow. Second, it should be easy to check compliance with the management plan. A planned-rest system would fit the above requirements probably better than other systems. If an entire unit is rested each year, followup checks would be easy for anyone to make. In developing a planned-rest system, it is important that the unit be tied to natural well defined areas. This may require combining allotments in some instances. Another requirement for managing the alpine allotments is that there must be sufficient land area to maneuver sheep herds.

F. Stocking Rates Guide

Following are general guides for tentative stocking of sheep on suitable range under a system of once-over moderate grazing on alpine areas of the Uinta Mountains.

Community	Sheep Days Per Acre	Acres Per Sheep Month
Carex rupestris	10 to 15	1.5 to 2.5
Geum-sedge	9 to 15	2 to 3
Dry meadow	15 to 30	1 to 2
Wet meadow	30 to 60	1/3 to 1
Sedge-grass	15 to 40	3/4 to 1.5
Open spruce	10 to 15	1.5 to 2.5

Under planned rest models the use may be increased some. However, present use records agree quite well with these estimates.

SUMMARY AND CONCLUSIONS

The alpine area of the Uinta Mountains is found on the exposed pre-Cambrian quartzite that makes up the core of the mountain.

Soils are shallow and rocky over much of the alpine area; however, moderately deep soils have developed on moderate slopes and more protected areas.

Soil development was reviewed for six major alpine sites: glacial moraines, fellfields, boulder fields, alluvial terraces, slopes below snowdrifts, and bottom lands.

Erosion rates are moderate over most of the alpine area regardless of the severe climate. The alpine turf is very tough and gives excellent protection to the soils once it has developed.

Normal and accelerated erosion are very difficult to separate. Frost is an important factor in breaking the turf and allowing the forces of erosion a chance to act. Livestock grazing and particularly the mechanical action of trampling is a heavy contributor to the turf breakup. Features due to frost action are frost hummocks, stone nets, stone stripes, and solifluction terraces.

Alpine vegetation is characterized by a patchwork of mixed plant communities which gradually grade into each other. Major communities are Carex rupestris-cushion plant, Geum-sedge, sedge-Geum, sedge-grass, wet meadows and bogs, dry meadow, and alpine shrub, with a closely associated open conifer type of minor importance.

There is evidence that alpine plant succession develops along three major lines of succession--namely, boulder field, fellfield, and alpine lake. All progressively develop toward a sedge-grass community of well drained, moderately deep soils, which is considered the nearest approach to the climatic climax found in this alpine area. Native forbs such as Geum rossii, Sibbaldia procumbens, Potentilla spp., Trifolium dasyphyllum, and Antennaria spp., are the major increasers and invaders in disturbed areas. Outside species are excluded because of the rigorous climate. Once an area has been disturbed, upward trend in condition is slow.

In range classification, the plant communities are grouped into six vegetation types. These are grasslands, wet meadows, dry meadows, perennial forb, shrub, and transition conifer. Poor condition of alpine areas is reflected primarily in reduced ground cover and low plant vigor.

Range suitability is based on a series of limiting factors. The major ones are accessibility, soil erodibility, and slope.

Alpine range of the Uinta Mountains can continue to be grazed provided the stocking is brought in line with capacity and management is raised to a higher standard. The major problems of the past have been overstocking and lack of management. It will be necessary to close critical areas to grazing.

Major considerations are range suitability, range condition, present and potential productivity of the various sites, and the kind of management system and the quality of livestock management provided by the permittee. Grazing capacity of suitable range should be based on a rate of moderate once-over use. Management planning must incorporate a system of use that provides for basic plant growth and soil stabilization requirements. It must also be fully coordinated with the needs of other resources and grazing animals.

APPENDIX

High Elevation Plants of the Uinta Mountains

Symbol			Upper El. Conifer			Alpine				
		Lakes	LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	1. POLYPODIACEAE - Fern F.									
CRAC2-	Cryptogramma acrostichoides R. Br.							x		
CYFR -	Cystopteris fragilis (L.) Bernh.		x	x						
WOSC -	Woodsia scopulina D. C. Eaton			x				x		
	2. ISOTACEAE - Quillwort F.									
ISBO -	Isotes bolanderi Engelm.	x								
	3. SELAGINELLAECEAE - Selaginella F.									
SEDED-	Selaginella densa densa Rydb.						x	x		
SEWA -	S. watsoni Underw.			x			x			
	4. PINACEAE - Pine F.									
ABLA -	Abies lasiocarpa (Hook) Nutt.			x						
JUCOS-	Juniperus communis L. var. saxatilis Pall.		x	x						
PIEN -	Picea engelmannii Parry			x						
PIFL -	Pinus flexilis James			x						
PICO -	P. contorta Dougl.		x							
	5. SPARGANIACEAE - Burreed F.									
SPAN -	Sparganium angustifolium Michx.	x								
SPMI -	S. minimum Fries.	x								
	6. POTAMOGETONACEAE - Pondweed F.									
POALT2-	Potamogeton alpinus var. tenuifolius (Raf.) Ogden	x								
POIL -	P. illinoensis Morong.	x								
	7. GRAMINEAE - Grass F.									
AGSA -	Agropyron saxicola (Scribn. & Smith) Piper							x		
AGSC -	A. scribneri Vasey								x	
AGSU -	A. subsecundum (Link) Hitch.		x	x						
AGTR -	A. trachycaulum (Link) Malte						x	x		
AGHU -	Agrostis humilis Vasey	x	x							
AGSC2-	A. scabra Willd.		x	x	x					
AGVA -	A. variabilis Rydb.			x			x			
ALAE -	Alopecurus aequalis Sobol.				x					
ALAL2-	A. alpinus Smith						x			
BRCI -	Bromus ciliatus L.						x			
CACAC-	Calamagrostis canadensis (Michx.) Beauv. var. canadensis				x		x			
CAPU -	C. purpurascens R. Br.							x		
CASC -	C. scopulorum M. E. Jones		x	x						

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Symbol		Lakes	Upper El. Conifer: LP	Upper El. Conifer: ES-AF	Upper El. Conifer: Meadow	Alpine: Wet Meadow	Alpine: Dry Meadow	Alpine: Alpine Turf	Alpine: Fellfield	Alpine: Boulderfield
	7. GRAMINEAE - Grass F. (Cont.)									
DAIN -	Danthonia intermedia Vasey						x			
DECA -	Deschampsia caespitosa (L.) Beauv.			x	x	x	x			
FEOVB-	Festuca ovina brachyphylla (Schult.) Piper							x	x	
GLBO -	Glyceria borealis (Nash) Batch.							x		
HEMO -	Helictotrichon mortonianum (Scribn.) Henr.								x	
HIOD -	Hierochloe odorata (L.) Beauv.				x					
KOCR -	Koeleria cristata (L.) Pers.							x		
PHAL -	Phleum alpinum L.						x		x	
POAL -	Poa alpina L.				x					
POEP -	P. epilis Scribn.						x			
POFE -	P. fendleriana (Steud.) Vasey						x			
POIN -	P. interior Rydb.			x	x					
POLE2-	P. leptocoma Trin.						x			
POLE3-	P. lettermani Vasey							x	x	
PONE -	P. nervosa (Hook.) Vasey	x	x							
PORU -	P. rupicola Nash						x	x	x	
POSA -	P. sandbergii Vasey		x				x			
TRSP -	Trisetum spicatum (L.) Richt.			x			x	x		
TRWO -	T. wolfii Vasey						x			
	8. CYPERACEAE - Sedge F.									
CAAB -	Carex ablata L. H. Bailey				x	x				
CAAIN-	C. albo-nigra Mack							x	x	
CAAQ -	C. aquatilis Wahl.				x	x				
CAAT2-	C. athrostachya Olney				x					
CAAT3-	C. atrata L.				x	x				
CAAU2-	C. aurea Nutt.				x					
CABE -	C. bella L. H. Bailey			x						
CABI -	C. bigelovii Torr.					x				
CABIA-	C. bipartita Bell. var. austromontana F. J. Herm.				x	x				
CABR4-	C. brunnescens (Pers.) Poir.				x	x				
CABU -	C. buxbaumii Wahl.			x						
CACA3-	C. canescens L.				x					
CACA4-	C. capillaris L.									x
CACA5-	C. capitata L.						x	x		
CACH -	C. chalciolepis Holm						x	x		
CADI2-	C. disperma Dewey		x	x						
CAEB -	C. ebenea Rydb.				x	x	x			
CAEG -	C. egglestonii Mack			x						
CAEL3-	C. elynoides Holm						x	x		
CAEN -	C. engelmannii L. H. Bailey								x	

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	8. CYPERACEAE - Sedge F. (Cont.)									
CAFE2-	Carex festivella Mack.				x					
CAGE -	C. geyeri Boott		x	x						
CAHA3-	C. haydeniana Olney						x	x		
CAHA2-	C. hassei L. H. Bailey		x	x						
CAHE5-	C. hepburnii Boott									x
CAHEE-	C. heteroneura var. epapillosa (Mack) F. J. Herm.			x	x	x				
CAHO2-	C. hoodii Boott			x						
CAIL -	C. illota L. H. Bailey				x					
CAIN4-	C. interior L. H. Bailey				x					
CAKE2-	C. kelloggii W. Boott				x					
CALA2-	C. lanuginosa Michx.				x					
CALE4-	C. leporinella Mack.				x	x				
CALI2-	C. limosa L.				x					
CAMES-	C. media R. Br. var. stevenii (Holm) Fern.				x	x				
CAMI4-	C. misandra R. Br.						x			
CANE3-	C. nelsonii Mack.				x	x				
CANI2-	C. nigricans C. A. Meyer				x					
CANO -	C. nova L. H. Bailey				x	x				
CAOC2-	C. occidentalis L. H. Bailey		x							
CAPA6-	C. paupercula Michx.				x					
CAPE2-	C. pelocarpa F. J. Herm.						x	x	x	
CAPH2-	C. phaeocephala Piper								x	
CAPR -	C. praeceptorum Mack.			x						
CAPS -	C. pseudoscirpoidea Rydb.							x		
CAPY -	C. pyrenaica Wahl.						x			
CARA2-	C. raynoldsii Dewey							x		
CARO3-	C. rossii Boott		x	x						
CARO4-	C. rostrata Stokes					x				
CARU -	C. rupestris All.								x	
CASAM-	C. saxatilis var. major Olney					x				
CASU2-	C. subnigricans Stacey						x	x		
CATO -	C. tolmiei Bott							x		
CAVE2-	C. vernacula L. H. Bailey					x				
CAVE3-	C. vesicaria L.					x				
ERAN -	Eriophorum angustifolium Roth.				x					
ERCH3-	E. chamissonis C. A. Meyer					x	x			
ELMA -	Eleocharis macrostachya Britton				x					
ELPA3-	E. pauciflorus (Lighf.) Link				x	x				
KOMY -	Kobresia myosuroides (Vill.) Fiori							x		
	9. JUNCACEAE - Rush F.									
JUAL -	Juncus albescens (Lange) Fern.					x				
JUCA -	J. castaneus Smith							x		
JUDR -	J. drummondii E. Meyer			x	x		x	x	x	

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			LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	9. JUNCACEAE - Rush F. (Cont.)									
JUHA -	J. hallii Engelm.				x		x			
JULO -	J. longistylis Torr.		x	x						
JUME -	J. mertensianus Bong.				x	x				
JUPA -	J. parryi Engelm.	x	x							
LUSP -	Luzula spicata (L.) DC.						x	x		
LUPA -	L. parviflora (Ehrh.) Desv.			x	x					
	10. LILIACEAE - Lily F.									
ALBR -	Allium brandegei S. Wats.		x	x						
ALBR2-	A. brevistylum S. Wats.		x							
LLSE -	Lloydia serotina (L.) Reichb.							x	x	
VECA -	Veratrum californicum Dur.			x						
ZIEL -	Zigadenus elegans Pursh		x	x						
	11. ORCHIDACEAE - Orchid F.									
HADI -	Habenaria dilatata (Pursh) Hook.				x					
SPRO -	Spiranthes romanzoffiana Cham. & Schlecht.				x					
	12. SALICACEAE - Willow F.									
SAAR -	Salix arctica Pall.				x					x
SABEP-	S. bebbiana Sarg. var. perrostrata (Rydb.) Schn.				x					
SACA -	S. cascadensis Cock.							x		
SADR -	S. drummondiana Barrett					x				
SAGE -	S. geyeriana Anderss.				x					
SAGL -	S. glauca L.		x		x	x				
SAMY -	S. myrtillifolia Anderss.				x					
SANIS-	S. nivalis Hook. var. saximontana (Rydb.) Schn.						x	x		
SAPL -	S. planifolia Pursh				x	x	x			
SAWO -	S. wolfii Bebb.				x					
	13. BETULACEAE - Birch F.									
BEGL -	Betula glandulosa Michx.					x				
	14. POLYGONACEAE - Buckwheat F.									
ERUMM-	Eriogonum umbellatum Torr. var. majus Hook .			x						
ERUMM2-	E. umbellatum Torr. monocephalum Torr. and Gray			x						
OXDI2-	Oxyrea digyna (L.) Hill									
POBI2-	Polygonum bistortoides Pursh					x	x	x		
POBIL-	P. b. var. linearifolium (S. Wats.) Small					x	x	x		
POVI2-	P. viviparum L.					x	x			

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High Elevation Plants of the Uinta Mountains

Symbol		Lakes	Upper El. Conifer			Alpine				
			LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	15. PORTULACACEAE - Purslane F.									
CLME -	Claytonia megarhiza (A. Gray) Parry			x						
LEPY -	Lewisia pygmaea (A. Gray) Rob.			x			x	x		
LEPYN-	L. p. var. nevadensis S. Wats.						x			
	16. CARYPHYLLACEAE - Pink F.									
ARCOS2-	Arenaria congesta Nutt. var. subcongesta (S. Wats.) S. Wats.			x						
ARFE3-	A. fendleri A. Gray								x	
AROB -	A. obtusiloba (Rydb.) Fern.						x		x	
ARRO -	A. rossii Rich.						x		x	
ARRU -	A. rubella (Wahl.) Smith						x	x		
CEAR -	Cerastium arvense L.						x			
LYAP -	Lychnis apetala L.							x	x	
LYDR -	L. drummondii (Hook.) S. Wats.			x				x		
LYKI -	L. kingii S. Wats.							x		
PAPU -	Paronychia pulvinata A. Gray							x	x	
SASAH -	Sagina saginoides (L.) Karst. var. hesperia Fern.		x							
SIACS-	Silene acaulis L. spp. subacaulescens (F.N. Williams) C.L. Hitch. & Mag.							x	x	
STLO -	Stellaria longifolia Muhl.		x	x						
STLO2-	S. longipes Goldie						x			
STUM -	S. umbellata Turcz.			x						
	17. NYMPHAEACEAE - Water Lily F.									
NUPO -	Nuphar polysepalum Engelm.	x								
	18. RANUNCULACEAE - Crowfoot F.									
ACCO -	Aconitum columbianum Nutt.				x					
ANMU -	Anemone multifida Poir.		x	x						
ANPA -	A. parviflora Michx.				x					
AQCOA-	Aquilegia coerulea James var. alpina A. Nels.									x
AQCOP-	A. c. var. pinetorum (Tides.) Payson									x
AQSC -	A. scopulorum Tides.								x	
CALE -	Caltha leptosepala DC.				x	x				
CLHI -	Clematis hirsutissima Pursh			x						
RAALM-	Ranunculus alismaefolius Geyer var. montana S. Wats.				x					
RAAQ -	R. aquatilis L.	x								
RAESA-	R. eschscholtzii var. adoneus (Gray) C. L. Hitch.				x			x		
RAESA2-	R. e. var. alpinus (Wats.) C.L.Hitch.				x			x		
RARES-	R. repens L. var. strigulosus Freyn.	x								
THSP -	Thalictrum sparsiflorum Turcz.				x					
THAL -	T. alpinum L.									x
TRLA2-	Trollius laxus Salisb.				x	x				

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High Elevation Plants of the Uinta Mountains

Symbol		Lakes	Upper El. Conifer			Alpine				
			LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	19. CRUCIFERAE - Mustard F.									
ARDR -	Arabis drummondii Gray		x	x					x	
ARHOR-	A. holboellii var. retrofracta (Graham) Rydb.							x	x	
ARLE -	A. lemmonii S. Wats.								x	
ARLY -	A. lyallii S. Wats.								x	
DRAU -	Draba aurea M. Vahl.						x	x		
DRDE -	D. densifolia Nutt.								x	
DRFL -	D. fladnizensis Wulfen								x	
DRNIE-	D. nivalis Lilj. var. exigua (Schulz) C. L. Hitch.								x	
DROL -	D. oligosperma Hook.								x	
DRRE2-	D. reptans (Lam.) Fern.						x			
DRSO -	D. sobolifera Rydb.									x
DRSTN-	D. stenoloba Ledeb. var. nana (Schulz) C. L. Hitch.						x			
PARY -	Parrya rydbergii Botsch.							x		
ROAL -	Rorippa alpina (S. Wats.) Rydb.	x								
SMCAA-	Smelowskia calycina C. A. Meyer var. americana (Regel & Herd.) Roll.								x	
	20. CRASSULACEAE - Orpine F.									
SERH -	Sedum rhodanthum A. Gray					x	x	x		
SEST -	S. stenopetalum Pursh		x	x					x	
	21. SAXIFRAGACEAE - Saxifrage F.									
MIST	Mitella stauropetala Piper						x			
RICEI-	Ribes cereum var. inebrians (Lindl.) C. L. Hitch.		x	x						
RIIN -	R. inerme Rydb.		x							
RIMO -	R. montigenum McCl.		x	x						
SAAD -	Saxifraga adscendens L.									x
SACE2-	S. cernua L.									x
SACR -	S. chrysantha A. Gray								x	
SADE -	S. debilis Engelm.			x						
SAOD -	S. odontoloma Piper		x							
SARH -	S. rhomboidea Greene			x	x	x	x			
	22. ROSACEAE - Rose F.									
DROCH-	Dryas octopetala L. var. hookeriana (Juz.) Briet.						x	x	x	
GERO -	Geum rossii (R. Br.) Ser.						x	x	x	x
IVGO -	Ivesia gordonii (Hook.) T. & G.			x						
POBI3-	Potentilla biennis Greene							x		
POCO8-	P. concinna Richards							x	x	

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High Elevation Plants of the Uinta Mountains

Symbol			Upper El. Conifer			Alpine				
		Lakes	LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	22. ROSACEAE - Rose F. (Cont.)									
PODI2-	Potentilla diversifolia Lehm.					x	x	x		
POFR4-	P. fruticosa L.			x	x		x			
POQU -	P. quinquefolia (Rydb.) Rydb.			x						
RUPA -	Rubus parviflorus Nutt.		x							
RUIDS-	R. idaeus L. ssp. sachalinensis (Levl.) Focke		x	x						
SIPR -	Sibbaldia procumbens L.						x	x	x	
SOSC -	Sorbus scopulina Greene		x							
	23. LEGUMINOSAE - Legume F.									
THMO2-	Thermopsis montana Nutt.		x	x						
TRDA -	Trifolium dasyphyllum T. & G.						x			
TRNA -	T. nanum Torr.								x	
TRPA -	T. parryi Gray						x		x	
	24. GERANIACEAE - Geranium F.									
GERI -	Geranium richardsonii Fisch. & Trautv.			x						
	25. CALLITRICHACEAE - Water Starwort F.									
CAVE4-	Callitriche verna L.	x								
	26. CELASTRACEAE - Staff-tree F.									
PAMY -	Pachystima myrsinites (Pursh) Raf.		x							
	27. RHAMNACEAE - Buckthorn f.									
CEVE -	Ceanothus velutinus Dougl.		x							
	28. VIOLACEAE - Violet F.									
VIADB-	Viola adunca Smith var. bellidifolia (Greene) Harr.						x			
VIMAP-	V. macloskeyi var. pallens (Banks) C. L. Hitch.					x				
VINE -	V. nephrophylla Greene					x				
	29. ELAEAGNACEAE - Oleaster F.									
SHCA -	Shepherdia canadensis (L.) Nutt.		x							
	30. ONAGRACEAE - Evening Primrose F.									
EPALA-	Epilobium alpinum L. var. alpinum		x	x	x					
EPALC-	E. a. var. clavatum (Trel.)C.L.Hitch.								x	
EPALM-	E. a. var. nutans (Hornem.) Hook.				x					
EPAN -	E. angustifolium L.		x							
EPGL2-	E.glandulosum Lehm.		x							
	31. UMBELLIFERAE - Carrot F.									
ANRO -	Angelica roseana Hend.		x							x

High Elevation Plants of the Uinta Mountains

Symbol		Lakes	Upper El. Conifer: LP	Upper El. Conifer: ES-AF	Upper El. Conifer: Meadow	Alpine: Wet Meadow	Alpine: Dry Meadow	Alpine: Alpine Turf	Alpine: Fellfield	Alpine: Boulderfield
	31. UMBELLIFERAE - Carrot F. (Cont.)									
LIFIT-	Ligusticum filicinum var. tenuifolium (S. Wats.) Mathias & Constance					x	x			
LOHE -	Lomatium hendersonii Coult. & Rose									x
ORAL -	Oreoxis alpina (A. Gray) Coult. & Rose								x	
POEA -	Podistera eastwoodae (Coult.& Rose) Mathias & Constance								x	
PSMO -	Pseudocymopterus montanus (A. Gray) Coult. & Rose								x	
	32. ERICACEAE - Heath F.									
ARUVU-	Arctostaphylos uva-ursi (L.) Spreng.		x	x						
GAHU -	Gaultheria humifusa (Graham) Rydb.						x			
KAPOM-	Kalmia polifolia Wang. var. microphylla (Hook.) Rehd.						x			
PYASP-	Pyrola asarifolia purpurea (Bunge) Fern.		x							
PYVI -	P. virens Schweiss		x							
VACA -	Vaccinium caespitosum Michx.		x			x				
VAMY -	V. myrtillus L.		x	x						
VAOC -	V. occidentale A. Gray		x							
VASC -	V. scoparium Leib.		x	x		x				
	33. PRIMULACEAE - Primrose F.									
ANSE2-	Androsace septentrionalis L.			x			x	x		x
DOAL -	Dodecatheon alpinum (A. Gray) Greene			x	x					
PRPA -	Primula parryi Gray			x	x		x			
	34. GENTIANACEAE - Gentian F.									
FRSP -	Frasera speciosa Dougl.		x							
GEAL -	Gentiana algida Pall.				x	x				
GEAM -	G. amarella L.					x				
GECA -	G. calycosa Griseb.								x	
GEFR -	G. fremontii Torr.				x	x				
GEPA -	G. parryi Engelm.				x	x				
GETE -	G. tenella Rott.				x	x				
SWPE -	Swertia perennis L.				x					
	35. POLEMONIACEAE - Phlox F.									
PHCO -	Phlox condensata (A. Gray) E. Nels.								x	
POEX -	Polemonium eximium Greene							x		
POPUD-	P. pulcherrimum var. delicatum (Rydb.) Cronq.								x	x
POPUP-	P. p. Hook. var. pulcherrimum								x	x
POVIM-	P. viscosum Nutt. ssp. mellitum (A. Gray) J. F. Davids.								x	x

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High Elevation Plants of the Uinta Mountains

Symbol		Lakes	Upper El. Conifer			Alpine				
			LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	36. HYDROPHYLLACEAE - Waterleaf F.									
PHGL3-	Phacelia glandulosa Nutt.									x
	37. BORAGINACEAE - Borage F.									
ERNAE-	Eritrichium nanum (Vill.) Schrad. var. elongatum (Rydb.) Cronq.							x		
LARE -	Lappula redowskii (Hornem.) Greene								x	
MECI2-	Mertensia ciliata (James) G. Don.						x	x	x	
MEVI2-	M. viridis (A. Nels.) A. Nels.									x
	38. SCROPHULARIACEAE - Figwort F.									
BEAL -	*Besseya alpina (A. Gray) Rydb.							x	x	
CAMI5-	Castilleja miniata Dougl.		x							
CAOC3-	C. occidentalis Torr.					x				
CAPU4-	C. pulchella Rydb.						x			
CARH -	C. rhexifolia Rydb.						x			
CASU3-	C. sulphurea Rydb.						x			
CAVI2-	C. viscida Rydb.			x			x			
MILE2-	Mimulus lewisii Pursh				x					
PEBRP-	Pedicularis bracteosa var. paysonia (Pennell) Cronq.						x			
PEGR2-	P. groenlandica Retz.				x	x				
PEPA2-	P. parryi Gray				x				x	
PERA2-	P. racemosa Dougl.			x	x					
PEPR2-	Penstemon procerus Dougl.								x	
PEUI -	P. uintahensis Pennell			x			x	x		
PEWH -	P. whippleeanus A. Gray			x			x			
VESEH-	Veronica serpyllifolia var. humifusa (Dickson) Vahl.				x					
VEWO -	V. wormskjoldii Roem. & Schult.				x					
	39. PLANTAGINACEAE - Plantain F.									
PLTW -	Plantago tweedyi A. Gray						x			
	40. CAPRIFOLIACEAE - Honeysuckle F.									
LOIN -	Lonicera involucrata (Rich.) Banks		x	x	x					
SARAM-	Sambucus racemosa L. var. microbotrys (Rydb.) Kern. Peeb.		x	x						
	41. CAMPANULACEAE - Bellflower F.									
CAPA3-	Campanula parryi Gray						x	x		
CARO2-	C. rotundifolia L.						x			
CAUN -	C. uniflora L.							x		
	42. VALERIANACEAE - Valerian F.									
VAED -	Valeriana edulis Nutt.				x		x			
VAOC2-	V. occidentalis Heller				x		x			

*No record but should be present.

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High Elevation Plants of the Uinta Mountains

Symbol		Lakes	Upper El. Conifer: LP	Upper El. Conifer: ES-AF	Upper El. Conifer: Meadow	Alpine: Wet Meadow	Alpine: Dry Meadow	Alpine: Alpine Turf	Alpine: Fellfield	Alpine: Boulderfield
	43. COMPOSITAE - Sunflower F.									
AGGL -	Agoseris glauca (Pursh) Raf.						x			
ANALM-	Antennaria alpina var. media (Greene) Jeps.					x				
ANCO -	A. corymbosa E. Nels.						x			
ANNEA-	A. neglecta var. attenuata (Fern.) Cronq.							x	x	
ANRO2-	A. rosea Greene		x	x						
ANUM -	A. umbrinella Rydb.			x						
ARCHF-	Arnica chamissonis ssp. foliosa (Nutt.) Maguire			x						
ARCO4-	A. cordifolia Hook.		x	x						
ARDI2-	A. diversifolia Greene			x						
ARMO -	A. mollis Hook.			x			x			
ARPA4-	A. parryi Gray			x						
ARSO -	A. sororia Greene				x					
ARMI3-	Artemisia michauxiana Bess.							x		x
ARNOS-	A. norvegica Fries var. saxatilis (Bess.) Jeps.							x	x	
ARSC2-	A. scopulorum Gray						x	x	x	
ASFOA-	Aster foliaceus Lindl. var. apricus Gray								x	x
ASGL -	A. glaucodes Blake						x			
CHAL2-	Chaenactis alpina (Gray) M.E. Jones								x	x
CIEA -	Cirsium eatoni (Gray) B. L. Robins			x				x		x
CIFO -	C. foliosum (Hook.) DC.		x	x						
CIPO -	C. polyphyllium (Rydb.) Petr.									x
ERACD-	Erigeron acris L. var. debilis Gray			x	x	x				
ERCOG-	E. compositus Pursh var. glabratus Macoun.							x		
ERLE -	E. leiomeris A. Gray			x				x		x
ERME2-	E. melanocephalus A. Nels.							x	x	
ERPE -	E. peregrinus (Pursh) Greene			x			x			
ERSI -	E. simplex Greene							x		
HAPA2-	Haplopappus parryi A. Gray		x							
HAPY -	H. pygmaeus (T. & G.) Gray							x	x	
HYACA-	Hymenoxys acaulis (Pursh) Parker var. arizonica (Greene) Parker						x		x	
HYGR -	H. grandiflora (T. & G.) Parker						x	x	x	
SEAT -	Senecio atratus Greene									x
SECA -	S. canus Hook.								x	x
SECR -	S. crassulus A. Gray			x						
SECY -	S. cymbalarioides Buek.				x					
SEERK-	S. eremophilus Rich. var. kingii (Rydb.) Greenm.			x						
SEFR -	S. fremontii T. & G.									x
SEMU2-	S. multilobatus Torr. & Gray							x		x

High Elevation Plants of the Uinta Mountains

Symbol		Lakes	Upper El. Conifer			Alpine				
			LP	ES-AF	Meadow	Wet Meadow	Dry Meadow	Alpine Turf	Fellfield	Boulderfield
	43. COMPOSITAE - Sunflower F.									
SESE2-	Senecio serra Hook.		x	x						
SEST2-	S. streptanthifolius Greene		x	x						
SETR -	S. triangularis Hook.		x	x	x					
SOMU -	Solidago multiradiata Ait.			x		x	x			
SOSPN-	S. spathulata DC. var. nana (A. Gray) Cronq.		x							
TALY -	Taraxacum lyratum (Ledeb.) DC.									x
TAOF -	T. officinale Weber		x	x		x				

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